TRAFFIC QUARTERLY

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THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL
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Small Town Traffic

IF YOU are fully acquainted with traffic news and traffic literature you might easily gain the impression that urban traffic problems are the most pressing.

If you are only reasonably well informed on its broader aspects you will recognize that the problem is critical and national.

There are some good reasons for the over-emphasis of the city problem. Organized interest, direct effort, professional advice and funds have succeeded in placing their problem in an understandable light within the mental grasp of those previously uninformed. Their efforts have stimulated interest and led to partially corrective measures.

The problem of the small town is different but not less important. Traffic problems can be as acute on Main Street as on Broadway, the driver attitude is much the same, or if any different, let us say, less professional. The reasons for the small town problem are not unlike those for the city—antiquated roads of another era, growing business and industry and the concentrated shopping districts.

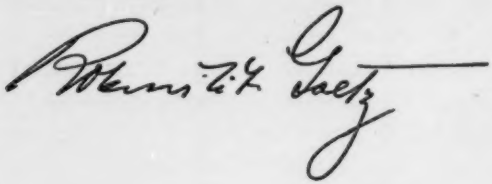
Most small towns grow without the benefit of planning. Some are civic minded and progressive, appreciating their responsibilities, anticipating their needs and endeavoring to meet them. This is not true of traffic. Small towns have become the bottlenecks of suburban and rural motor travel.

Many are lacking in knowledge and complacent in their efforts to meet their traffic problems. With the mounting flow of traffic and their wishy-washy methods they inescapably find themselves submerged in a conflict of individual and selfish interests with a do-nothing policy. Eventually they become something to be avoided and finally stagnate. Many residents of the community fully appreciate that their traffic problem is intolerable and inexcusable as a result of poor management. Ironically, they, or an influential portion of them, are the first to oppose a logical change.

In these days of rapid travel and communication there is not much excuse for a form of municipal government or administration that continues to tolerate such chaotic traffic conditions, blind to its

disadvantages and inefficiency and insensible to the contempt of the citizens of the community and the increasing wrath of those whose limited itinerary compels them to motor through it.

The ineffectual and haphazard small town methods now in vogue are bewildering to the conscientious effort and best intent of the law-abiding part of the motoring public striving to be good drivers.



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Safety Commission Procedures in Connecticut

GOVERNOR JAMES L. McCONAUGHY

Dr. McConaughy is Governor of Connecticut. He is Honorary Chairman of the Connecticut Highway Safety Commission of which he has been a member since 1937. Governor McConaughy was president of Knox College at Galesburg, Illinois, from 1918 to 1925. From 1925 to 1943, he was president of Wesleyan University, Middletown, Connecticut. From 1943 to 1945, he was Deputy Director of the Office of Strategic Services, Washington, D. C. He was Lieutenant-Governor of Connecticut in 1939–40. Governor McConaughy received his bachelor's degree from Yale in 1909; his Ph.D. degree from Columbia University in 1913. He has been President of United China Relief since 1942.

CONNECTICUT received both the National Safety Council and the AAA Grand Awards in 1946. Connecticut is the first state to receive both awards in one year and the first state to win the Safety Council's Grand Award three times. Every year except one since 1937, Connecticut has been singled out for national recognition. But the best results of safety efforts in the state are found in the reduction of the number of persons killed annually in highway accidents.

Connecticut's worst year for traffic fatalities was 1935 when 485 persons were killed. The record for the previous nine years was alarming enough, but the 1935 total showed an increase of 36 per cent. Nearly every year since the State's Highway Safety Commission was formed, Connecticut's fatality record has decreased and last year's total of 244 traffic deaths represents a decrease of nearly 50 per cent as compared with the 1935 figure.

Such state agencies as the Motor Vehicle, Police, Highway and Education Departments have waged relentless campaigns against death on our highways. The Highway Safety Commission, in addition to coordinating efforts of the other departments, has conducted an intensive campaign of public education. Safety has been no accident in Connecticut. It has been a never-ending task. Improved highways and stricter enforcement of laws have been important fac-

tors, but most important is the acceptance of laws plus good driving practices of Connecticut motorists.

Safety Commission's Procedure Explained

Such acceptance stems from safety education efforts during the past ten years. Newspapers have been generous with space. Radio broadcasts include safety messages every day, and this year billboards carry safety messages on a year-round basis. Connecticut motorists have become safety conscious.

Launched in an era of centralized control, the Connecticut Highway Safety Commission's plan to combat highway hazards was one of decentralized efforts. The Commission, composed of twenty-one members, is broken down into various committees such as legislative, public relations, automobile inspections, education, engineering, enforcement, pedestrian safety, industrial safety and police cooperation. The joint efforts by these various groups provide the program on a state level, but the program in some form or another gets to every one of the 169 communities in the state.

During the early days of the Commission, community, county and state safety associations were formed. Membership of the community committee consists of public-spirited persons. Each committee has a chairman and various sub-committees following, generally, the Commission's sub-sections. The purpose of these community committees is to study local problems of safety affecting the community. The county safety association consists of the chairman of the community committees.

The county committees study the problems of street and highway safety as affecting the county and work for improvements recommended. The State Safety Association consists of twenty-seven persons elected by the county associations. The state association supplements the work of the Commission, coordinates activities in general and functions in an advisory capacity.

Good Highway Control Is Necessary

Thus, the Connecticut Safety Program includes state phases of education, engineering and enforcement supplemented by similar pro-

grams in all of the communities. State agencies on one hand are concerned with safety on state highways. Cities and small communities, generally, strive to eliminate local hazards, calling upon state agencies for assistance when necessary and practicable.

Safe travel cannot be accomplished without good highways and highway control and in this field the Connecticut Highway Department continues the work that has brought repeated national recognition in recent years. The Merritt Parkway and completed sections of the Wilbur Cross Highway are concrete examples of modern safe highways. Their safe features however did not come without intensive, comprehensive planning, nor without revision of earlier plans. The traffic picture has so changed since the Merritt Parkway was first conceived that, after initial construction began, it took constant revision and the scrapping of plans to make it the modern highway it is today. Studies and improvements continue, not only on these two arteries, but on all state-maintained roads and highways.

Traffic Research Used in Connecticut

The Division of Highway Control, through its Traffic Engineering, Highway Markings and Permit Sections, greatly aids the safety program by supplying traffic studies, formulating regulations and installing control facilities. Studies and surveys are conducted by the Traffic Engineering Section and the data are carefully analyzed to determine measures for improving traffic conditions.

Our Highway Department reports that before a regulation is effected or a control facility installed or removed, every phase of the problem is studied with the ultimate goal of insuring the complete safety, convenience and comfort of the motoring public. Permits are issued to break into pavement for such things as installation of utility poles, but only after the effect upon the roadway and the public has been considered carefully.

Since the end of the war and a resumption of heavy traffic, the activities of the Traffic Engineering Section, Highway Markings Section and Permit Section of the Division of Highway Control have increased in an effort to maintain arteries in a safe condition and to avoid accidents and congestion. This has been accomplished through the work of issuing permits, directing and maintaining highway

signs, pavement markings, delineators, traffic control devices, channelization projects and the re-design of congested intersections and portions of roadway. The work reduced materially or eliminated entirely the occurrence of accidents and congestion at many locations and at the same time permits safe and rapid transportation.

Analysis of accident locations has played another important part in our safety program. Since 1940 our Traffic Engineering Section has kept a file of all accidents occurring on state highways. Each of these accidents is spotted on a large scale map and indicates at a glance the location of accidents which should receive immediate attention. The Traffic Engineering Section analyzes and prepares reports on approximately 9,000 accidents a year. In addition, special studies are made constantly for the State Traffic Commission, Highway Safety Commission and the National Safety Council.

Night Lighting Studied to Ease Day Loads

While surveys and planning continue for the highways of the future, the snow removal, sanding, pavement and shoulder maintenance work of the Highway Department continues with miles and miles of pavement markings and thousands of signs in evidence on all portions of the state's highways. At present, the department reports that it is making a further study of adequate highway lighting and roadside delineation so that night travel can be made at the same speed and with the same degree of safety as in daytime. Good highway lighting, it is hoped, will tend to encourage night travel and lessen excessive day loads.

Enforcement of motor traffic laws, generally, never has been a serious problem in Connecticut. The State Police have followed a fair but firm enforcement policy that has brought good results. State policemen say the majority of Connecticut drivers want to observe traffic regulations and try to drive safely. Strict action, therefore, is necessary for only a small group. Careful training of policemen for traffic work has received special attention since the state first became interested in highway safety and it has produced good results. The system of handing out warning tickets for minor speed violations has

brought good results, it is believed, and has brought about a more wholesome respect for laws enacted for the protection of motorists and pedestrians.

Radar and Helicopter Are Added Checks

The Connecticut State Police are well to the forefront in the field of modern experimentation in traffic control work. Last year, radar was employed for the first time in the state, and its use to check speed has been well received. While its use as an enforcement aid has not been completely determined, its survey value is unquestioned. The old system of stretching tubing connected with the checking device across the highway served as a warning to oncoming motorists that their speeds were being checked and resulted in a natural slowing down. With radar, inconspicuously located, accurate and normal speeds can be recorded at various locations without the driver being aware of the check.

Another modern application of traffic control has been tried out successfully during periods of heavy traffic. The use of cruiser cars and two-way radio has been supplemented by use of a helicopter that permitted air-ground observance and correction of traffic jams. A traffic jam spotted from the air is made known to state policemen in cruiser cars and the situation soon is remedied. Such air-ground work facilitates correction of a situation which often resulted from a few slow-poke drivers.

Another feature of the traffic enforcement program has been the close cooperation of the department and the police in the local communities. The cooperation has resulted in the development of a high degree of efficiency in the state's enforcement program. The cooperation of the Connecticut Chiefs of Police Association, particularly during special projects, has been a big factor in the state's safety program.

Liberal Policy on Speed Arrests

While legislation provides for strict enforcement of traffic regulations, arrests, generally, are not made as a result of speedometer

recording alone. It has long been the policy of state policemen to encourage a steady, safe flow of traffic and to make arrests only when speed constitutes recklessness resulting from prevailing conditions as well as the actual speed of the vehicle.

Practically every activity of our State Department of Motor Vehicles has some contribution to make to the highway safety program. Some are more important than others. Even such a seemingly unrelated phase as the collection of gasoline taxes is statistically important in that it provides a yardstick for motor mileage which aids in estimating accident rates. More important activities include collection and publication of accident data, examination of new operators, operator control hearings, examination of motor vehicles, assisting the safety education program in the schools and through the Engineering Section's specifications for manufacturers so that devices may measure up to approved standards.

Published Accident Data Help Drivers

The statistical data of our Motor Vehicle Department has been widely used throughout the country over the years and has been of invaluable assistance to our other state departments interested in safety. Motor Vehicle Department data show the how, when, where and sometimes the why of accidents and provide the basis for the necessary corrective action. Publication of such data has done much to educate the driving public as regards the existence of hazards so that individual awareness may result in more cautious driving.

Connecticut was one of the first states to require examination of new drivers. The requirement was begun in 1917. Examiners have sought continuously to be sure that drivers know motor vehicle laws, rules and regulations as well as to demonstrate ability to drive. Many states have copied the Connecticut system of driver examination. The system continues to prove its worth in our own state.

A plan for license suspension may be found in the hearings section of the department. State law arbitrarily dictates suspension of licenses for various offenses, and others may be suspended by the Commissioner. In any event, before such drivers are reinstated, a hearing is held to determine the disposition.

Point System Warns Violators

In an effort to make drivers aware of the seriousness of violations, a new "point system" recently was begun. It is a corrective and educational program: warnings may be sent drivers to keep them out of serious trouble. A numerical rate is provided for in a table of conviction values. When a guilty operator is credited with an accumulated point total, he is informed of his record and told he may get into serious trouble if his record does not improve. A continuance of violations may result in a hearing to show why the license should not be suspended.

Licensed auto dealers and repairers soon will be authorized to make free official inspections of motor vehicles under the direction and supervision of the Motor Vehicle Department. This system will provide a convenient type of inspection to take care of defective equipment on a voluntary basis.

All of the above activities of the Motor Vehicle Department not only provide good administration, but represent valuable contributions to the state safety program.

Safety Education Compulsory Since 1937

Safety education in the schools has kept pace with other departments since the Highway Safety Commission came into being. In 1936 only six towns in the state were teaching safety. In 1937, an act was passed requiring that safety education be taught in all schools. Safety work has included regular classroom courses and in some cases actual driving classes. The latter phase will be intensified this year and legislative action will permit greatly increased safety education activities in schools of the state in the future.

While the State Highway Safety Commission continues its efforts to educate the driving and walking public, and to coordinate engineering and enforcement phases, the success of the state program rests with local civic, enforcement and engineering agencies.

Thus the Connecticut safety program is one which permits assistance of state agencies to local groups. Since the early days of the Commission, every factor and method found by experience to be of

value has been retained, and as opportunity and facility permitted, innovations were added.

Laws, rules, regulations, better highways, better enforcement, better education on state, county and community levels may contribute to the excellent comparative records made by Connecticut, but it is the individual acceptance of responsibility that continues as the most important factor.

That has been the Connecticut way.

Highways Influence Civic Growth and Industrial Development

CHARLES M. NOBLE

Mr. Noble is Chief Engineer of the New Jersey State Highway Department. He has had thirty years of experience in engineering in seven states, and at advance bases in the Pacific during World War II. He was an engineer for the Port of New York Authority on the following projects: Outerbridge Crossing, Goethals Bridge, Bayonne Bridge, George Washington Bridge and the Lincoln Tunnel. He was Special Highway Engineer on the Pennsylvania Turnpike project. As a Naval Reserve Commander during the war, he directed construction of airfields and docks for eighteen months in Alaska and the Aleutians and did engineering reconnaissance in China behind Japanese lines. He received the Legion of Merit and Bronze Star medals in the war, and the Arthur Wellington prize of the ASCE for his study on "The Modern Express Highway." As a member of the Highway Research Board, he is Chairman of the Committee on Effect of Limited Access Expressways on Existing Street Systems.

IN DISCUSSING the influence of highway location and type on community growth and industrial development it is first necessary to understand the tremendous economic forces let loose by the automotive vehicle. This understanding should include the potentialities for beneficial exploitation of these forces. This article will sketch, therefore, the historical background of highway transportation and then fill in the picture with the brush strokes of individual technic.

The road came into being with the invention of the wheel in the dim dawn of man's struggle toward civilization. For thousands of years after its advent, however, the concept of the road remained unchanged, static and crude because the speed of the vehicle using it was constant. Suddenly, about a moment ago on the scale of human history, the revolution of the automotive vehicle burst upon the world and a vista of more rapid free-wheel transportation began to unfold.

It has taken forty-seven years for the human mind to adjust itself to this revolution and begin to grasp the tremendous significance of the motor vehicle and highway transportation to economic, industrial and community life. In addition, the increased speed, size and weight of the vehicle has forced a new concept of the physical and geometric characteristics of the highway structure and compelled our use of the laws of motion in highway design as well as our recognition of human psychology.

In early ages, progress toward civilized society and government unfolded in ratio to the means available of communication and transportation. The land had to be *accessible* to be useful. A diamond or gold mine is worthless unless we can get to it and from it—economically. Consequently, civilization flourished along the seas, waterways and caravan routes of the world. The Roman Empire in its march toward world domination used all natural means of communication and transportation and developed a system of military roads that served not only the uses of conquest but served also as the avenues of commerce to exploit the conquered areas.

More recently the stagecoach and post-road systems in Europe and America provided a means of more adequate and efficient overland communication and transportation. But this development was cut short by the railway era, which substituted mechanical for animal power. As long as man was chained to animal motive power, his opportunities for expanded community and industrial development were limited.

When Materials and Labor Meet

With the advent of the railway began the real industrial, agricultural, commercial and community development of America. The city, the community, became the hub. It became possible to gather products of mine, forest, and soil from a great distance and to deliver them rapidly and economically to the community where labor was available for further processing. Thus industry and commerce gravitated to the city where raw materials and labor met. The commercial and industrial development of the nation took place along the railway lines of America and the economy of the nation revolved around rail and water transportation.

At the turn of the twentieth century, settlement of the United States was virtually complete, and rail and waterway systems were nearly stabilized as to location. Industry was settled in communities where labor was available and where raw materials could be delivered economically by rail or water. But commerce and retail trade were confined to areas within walking or horse-and-buggy distance of the customer and worker. Although this range was widened by extensive construction of street car and trolley systems it was still confined to walking distance from the fixed rails of the trolley. The range of the farmer's market was confined to a half-day's journey by team and wagon. This period at the turn of the century represented the culmination of the horse-and-buggy-railway economy. It was limited by fixed rails.

The automotive vehicle brought a new concept to transportation—flexibility. The first twenty years of the century were devoted to perfecting the mechanical design of the vehicle. It was made dependable and economical to operate, and efficient manufacturing processes were developed until its selling price placed it within reach of the average American citizen. During this period few people recognized the potentialities of the motor car or anticipated the revolution it would cause in American economy or in our cultural and social values.

Fixity Versus Flexibility

After the close of World War I, the automotive era began in earnest. In the period between the two wars the highway construction program accomplished in the United States was without parallel in the history of the world. This program, in twenty years, provided a network of all-weather highways from the Atlantic to the Pacific and from the Canadian border to Mexico. There are few areas in the United States inaccessible to a motor car at all times of the year. Without this system the automotive era would have withered and died and great industries would still be unborn.

It may be asked, what is the difference between the buggy-railway economy and the economy of the automotive age? Essentially the difference is between fixity and flexibility—between mass transportation and personalized transportation.

Never before in the history of the world has it been possible for man to move so freely, so flexibly, so swiftly, so far, and with such economy along the face of the earth. The highlights of this new service to national economy may be summarized as follows:

(a) The motor car is ready instantly at all times at the door to carry the individual or his family along a personally selected route, arriving at a convenient predetermined time. It renders complete door-to-door service without added expense or vexing delays in changing from one form of transportation to another.

(b) The farmer can travel with ease and comfort protected from the weather a greater distance in one half-hour than formerly in one half-day. This widens the economical radius of productive lands. It gives the farm population *more time* to devote to crops, to the business of disposing of crops, and for social life, leisure, recreation and the pursuit of cultural occupations.

(c) It brings children to schools instead of schools to the children. This increases the efficiency, economy and quality of education.

(d) The worker is brought to the industrial plant and not the plant to the worker, permitting more economical and logically zoned plant location. It offers more space for plant layout and design with improved working and recreational facilities, and it opens up additional sites for industry, thus developing tax ratables and employment over greater areas. This will result in a more logical, efficient and widespread utilization of land within a state.

(e) The motor bus provides semi-personalized, at-the-curb mass transportation facilities with opportunity for adjustment of routes to follow trends of shifting population and the establishment of new industrial areas as well as a flexible rural service not hitherto available.

(f) Motor transportation expands shopping opportunities encouraging economical large-unit merchandising and the cash-and-carry principle. This increases the annual national sales volume and gives the mass of the people more of everything for less expenditure.

(g) Opens recreation areas and facilities to all the people improving the national health and morale and promotes the prosperity

of regions whose sole natural resource consists of recreational terrain or water.

(h) Provides store-door delivery, resulting in more economical transportation and handling costs, lower inventories, greater turnover with the capital employed, less storage space and fresher merchandise for the consuming public.

(i) Provides rapid direct farm-to-market or processing plant delivery service with economy and without rehandling expense or delay. This results in extensive milk pick-up services, field loading of crops, over-night delivery of fresh vegetables, poultry, eggs and live stock up to distances of 300 miles, with forty-eight hour delivery up to 1,000 miles, greatly improving the quality, quantity and variety of fresh foods, thus promoting the standard of living and health of the American people.

(j) Supplements other forms of transportation and reduces the necessity of constructing or maintaining uneconomical fixed plants.

(k) Promotes greater and more economical utilization of the land and thus develops the country and induces expanding tax ratables.

(l) Will promote and make possible the eventual elimination of slum areas when planning agencies grasp the significance and opportunities of the automotive age.

(m) Spreads the economy of travel and the transport of commodities to all classes of people and to all sections of the nation's economy, thus affording the great mass of the people the opportunity of healthful, educational and recreational travel resulting in welding the nation more closely together and the reduction of the cost of commodities and manufactured products, therefore promoting a higher standard of living in America.

(n) Enables a concept of distance to be based on time rather than miles, i.e., one often hears the expression that a certain place is so many minutes away or so many hours away.

(o) Promotes the development of off-street (highway) service centers with adequate parking facilities which offer convenient, safe and economical shopping facilities to the public. Compatible with

good zoning principles, preserves the roadside appearance and affords highway authorities the opportunity of providing safe, convenient access and exit facilities which will avoid crippling conflict with through traffic on the main arteries.

(p) Because of greater flexibility for expanded service with economy the automotive age generates an expanding economy and creates wealth at the national, state and local level.

Some of the services and trends outlined above are already fully established and generally recognized; others, in initial stages of development and exploitation, are recognized less generally; still others in their infancy are understood but dimly.

Sad Comment on Our Ability to Plan

Flexibility and utility of the motor car are recognized universally. But the economic benefits it bestows on both citizen and nation are not so well understood. Nor do we clearly grasp the implications of further beneficial effects from wise community and facility planning, keeping ever in mind the requirements of the automotive age. More careful zoning is a case in point. It is a sad commentary on our ability to plan affairs when, after a public body has constructed an excellently designed and adequate highway facility at public expense for the use and comfort of all the people, we see within a short span of years indiscriminate and unregulated roadside development by abutting owners—an unwise development that transforms a once community asset into a road-side slum with greatly decreased traffic efficiency and increased accident potential.

Automotive era type planning and zoning should eliminate such deteriorating community effect and its waste of public funds. But such planning must not deny or even discourage the right of commerce and industry to do business on an economical and effective basis. It is practical and compatible for business to be done satisfactorily when zoned intelligently in such a way as to avoid the depreciation of community and highway. It must be recognized that industry and commerce are the life blood of America. Without them all else would cease to exist.

Planning must recognize the nature of the automotive revolution and the principles required to further the beneficial effects of the automotive age and utilize such principles in the practical affairs of rebuilding America. We must avoid the mistakes of those generals who plan for the next war on the basis of past wars. Automotive age planning must look forward not backward.

The trend toward larger merchandising units, super-markets and service-center developments is significant. These forms are emerging under the pressure of competition, the necessity for economy and the realization that the customer is motor-borne. Service Center facilities invariably provide parking space for the customer but to date the forms are crude; often ugly. Little has been done to integrate them into community and highway planning.

It is entirely feasible for these facilities to be reasonably consolidated and set off from the highway in an adequate ground area with a vehicular access properly connected to the public highway in a way that will promote safety and avoidance of traffic interference. Proper attention to aesthetics, landscaping with shrubbery and coordinated design, will result in customer and public favor. It will advance community planning and promote ideals of the automotive age.

Highway-Planning a New America

There is evidence that many leaders of industry recognize the problems and responsibilities associated with the automotive revolution. More and more industrial plants are being located in the open country on large tracts of land and provided with ample parking facilities for the workers on the principle that it is more economical for the worker to go to the plant than for the plant to go to the worker. Often an industrialist considers that adequate highway connections are more important to plant economy than first quality railway facilities.

Many of these plants are of superior aesthetic design and are surrounded with tastefully arranged landscaped areas. In spite of these progressive developments more over-all community and regional planning and more detailed traffic planning is necessary in order that

the concentration of worker and delivery traffic may be adequately accommodated and diffused over the highway network. At many plants more than 10,000 workers arrive by motor car at approximately the same time each morning and leave in the afternoon. The swing toward 24-hour operation will relieve this problem but will not eliminate it.

Diffusion of industry will result in more effective land use, expansion of tax ratables, more even distribution of population with better living conditions, wider employment opportunities and in a reduction of traffic congestion.

The impact of the automotive revolution caught the cities and communities of America unaware. These communities were developed and matured during the horse and buggy and railway economies. In general, they are wholly unsuited to the efficient use of the motor car. As a consequence many cities are experiencing distress, losing population and suffering a decline in taxable ratables. These cities have an investment of public funds of some billions of dollars in public works, schools and hospitals, and it is only wise conservation that this investment be safeguarded by adjusting conditions so that these facilities will continue to serve the public in the years ahead.

It is unthinkable that these cities and this investment should waste away. This can be prevented only if community and city are revitalized. Bold farseeing community planning and action that recognizes the needs of our automotive age will be required to save many cities from continued retrogression by planning a more efficient use of land. This can make the city accessible and suited to automotive traffic. It can clear slums or make them into better places in which to live and work. These potentialities so far are dimly seen, and the ways and means to arrest the retrogression by eliminating undesirable features while preserving and strengthening the desirable ones are not too clearly recognized.

Highways and Our Better Rural Life

Perhaps no phase of the automotive revolution has been more striking and beneficial than the emancipation of the farmer. One need

look back only thirty years and compare the lonely isolated existence of most farmers to bring home the change wrought by motor vehicles. While these changes have been revolutionary, the end is not yet, for further possibilities of improved rural transportation, improved social and cultural life for farmers are coming.

The consolidation of rural schools made possible by the school bus has lifted the level of rural education. It is entirely possible that this principle may extend to urban areas. With the adoption of training films and the techniques developed by the armed forces in their training programs, education may be more rapid, efficient and thorough. It is probable that more pupils can be effectively handled by one teacher thus achieving economy while at the same time further raising the level of American education. Automotive transportation will make this feasible.

The general public does not yet appreciate the significance of the motor truck. If motor transport came to a stop overnight, the American way of life as we understand it would cease abruptly. In fact our population, particularly in urban areas, would face starvation. Trucks transport significant portions of all vegetables, milk and fresh foods from farm to market, and practically all foodstuffs are trucked from wholesaler to retailer. Without motor transport, essential and critical materials could not be delivered to industrial plants, and the wheels of industry would stop. Widespread unemployment, distress and an economic crippling would result.

Thirty per cent of all our trucks are owned by farmers. A large number of the remaining trucks are used to deliver farm products to market. The remainder, exclusive of government-owned trucks, are used in commerce and industry. Without the services of the motor truck the selling-price of food, the necessities of life and all merchandise would be higher. The truck is interwoven in the American way of life.

A problem directly resulting from motor vehicle operation is the accident situation. Horses ran away and vehicles turned over before the motor car. There still would be accidents if motor vehicles had never been developed. But today the large number of traffic accidents, the appalling loss of life, and the staggering economic waste from these accidents demonstrate that greater effort should be made

to eliminate the causes of traffic accidents. Great effort and some progress has been made in this field, but better results must be obtained.

Enthusiastic promotion programs for highway construction, so vigorously carried forward during the motor vehicle's development stage, have disappeared. Complacent lethargy replaces them. The public is quite aware of the convenience of the motor car. But the public fails to recognize the essential nature of an adequate highway system for using fully the automotive age and for bringing to the American public the full fruits of expanding markets, employment opportunities, healthy growth of undeveloped areas, the stabilization and revitalization of urban areas, an expanded industry, additional tax ratables and enlarged opportunities for pleasure and recreation.

Some believe that sufficient highways have been built to satisfy the needs of the nation; that additional highways are a luxury. In many areas this is far from the case when the existing highway plant is measured for adequacy in terms of freedom of movement, freedom from traffic congestion, ability to afford the traveller a reasonable average speed in keeping with the tempo of modern life and freedom from built-in accident hazards. The automotive vehicle without a road is as useless as an airplane without a landing field.

This, then, is the background of the highway transportation-automotive era portrait. *Automotive Era* should not mean the bare bones of a mechanical age, naked and stark against a background of misery and ugliness. The term should envisage a graceful figure clothed for better living and the fulfillment of aesthetic and cultural opportunities. Its objective should be the establishment of permanent values and the elimination of the jerry-built and Wild West character of community facilities. America should achieve dignity and maturity.

A Design for Automotive Living

What kind of highway transportation system is required to permit the automotive age to mature and bring to fruition a more abundant life? What kind of system and types of highway are required to use our national resources fully and to advance the prosperity and wel-

fare of nation, state and community? What system is required to expand and stabilize industry and commerce?

The system must be well planned, comprehensive, coordinated. It must be located along "desire lines" of traffic. It must be flexible. And it must provide the character of service required by the traffic of our automotive age in every situation.

Today's and tomorrow's highway must be of a type, location and design that will eliminate delay and congestion, relieve the driver of strain, and be free from accident potential. Each highway should be so located, of such type, and so designed, as to serve best the particular traffic needs of nation, state, countryside and community.

To understand the problem clearly, it is necessary to outline the general groups into which highways fall, and the kind of service each renders. In broad terms, our highway transportation system is composed of three general groups:

1. The feeder system
2. The ordinary state highway system
3. The freeway and parkway system

The feeder system consists of those roads that primarily serve the land directly and that collect and diffuse traffic. This group includes urban streets that provide access to property and do not serve as through-traffic arteries. The system is of the greatest importance. It makes the land accessible for use. Without accessibility, land is worthless. Witness millions of undeveloped but fertile land in various parts of the world, entirely idle because transportation accessibility is lacking.

The ordinary state highway system collects traffic from feeder roads and carries the great burden of traffic between centers of population. It is a town-to-town system. In addition it serves the land along its borders; free access is permitted adjacent land owners. Such highways are not entirely local; they are of statewide significance. In fact, many are of national import.

The freeway and parkway system consists of controlled-access highways. It serves as relief valve for congestion. These highways do not serve the land directly because free access to them is denied abutting property owners except at specially designed traffic interchange

facilities. They are justified by intolerable congestion on land-service highways, where traffic density with costly, nerve-racking delays from red lights, intersections at grade, left turns and disturbances caused by vehicles entering and leaving the highway at will greatly reduce freedom of movement and increase accidents. The most pressing application of the freeway and parkway principle is in highly developed and industrialized urban areas where traffic congestion is strangling further development.

The detrimental effect on the economic life of countryside, community and individual from inadequate, poorly located highways is so pronounced that every precaution should be taken to assure proper type and location. Highway planning, therefore occupies a preeminent position in highway affairs. This is sharply in contrast with the situation twenty years ago.

Early in the development of the motor age, highway planning was comparatively simple. The need to connect centers of population with passable roads through rural areas was obvious. Instinctive judgment of engineers was adequate to meet and promote the development of the motor car. But as motor transport integrated itself into life and industry, the problem became more complex. Today an instinctive approach will no longer suffice. More analytical methods are required in order that highway transportation will pace the tempo of industrial and social development. Thus it is vital that continued development and expansion of this system should be wisely, carefully and scientifically planned; that all available data be used.

Great Value of Public Roads Administration

Modern highway planning utilizes the scientific techniques developed over the past dozen years by the highway planning surveys initiated by the Public Roads Administration. These techniques employ data on existing traffic patterns, volumes, existing road capacity, origin-and-destination and desire-lines of traffic, benefit-cost ratio, population growth and trends, land use, recreation areas and location, growth and trends of commerce and industry. It is also necessary to gather data from national, state and local agencies in order

to integrate the development plans of these groups into the highway net.

It is necessary to learn the trend of industrial and agricultural development, to ascertain where water power and water supply reservoirs, airfields, canals, railways, recreation areas, state and national forests and military installations are planned in order that the highway will serve these facilities effectively and not conflict with them. It is also essential that the reports of local planning bodies be kept on file and reviewed so that there will be complete coordination through all levels of government from top to bottom.

When these data are properly collated and coordinated, the types and general locations of the roads comprising an economic highway transportation system are indicated. Detailed engineering surveys on the ground determine the precise location of the particular road under consideration. The objective is to place the highway in a location indicated by traffic; a location that will at the same time best serve the needs of people in the territory, develop the land fully and promote proper commercial and industrial expansion. These objectives should be reconciled with the plans of national, state and local planning agencies.

As stated previously, the feeder system serves the land directly. For clarity the system may be further sub-divided into:

(a) Strictly local roads or streets which are solely for access, and,
(b) Principal feeder routes which serve both access and transportation requirements. The County and Federal Aid Secondary systems are examples.

The location and frequency of highways in the feeder system depend on what the land is, or can be, used for. In agricultural areas, the road should provide access for farms, and its location should serve farms most effectively, care being taken to avoid, when feasible, preempting or damaging tillable ground by economic severance. These roads should be sufficiently frequent to open up for production all available fertile land in the territory.

In areas devoted to mining, timbering or other industry, the road should not only be located to serve the access and transportation

needs of these industries effectively, but also the system should be so planned that workers from centers of population will have ready and reasonably direct access to the plants. Where residential and business areas are involved, it is obvious that the frequency of roads and streets must be greater to make maximum use of the land; and that the land will be used more intensively than in rural areas.

Location of feeder roads will depend on land use, where people are living or will want to live; where they work, the available employment, natural resources, commercial and industrial development or potentialities. In general, traffic capacity is not a problem, but *adequate quantity* is essential. Eighty per cent of the 3,000,000 miles of highways in the United States carry an average *daily traffic of twenty-two vehicles or less.*

Traffic Potential Must Be Determined

Directness of route and recognition of the economic principles of traffic operation are important considerations. To serve the needs of the people effectively the state highway should be located along the center of gravity of the desire-lines of traffic.

The traffic capacity of a highway is of paramount importance. It is necessary that the traffic volume potential be determined so a sufficient number of lanes can be provided in each traffic shed. Due regard should be paid to time delays occasioned by congestion. In urban areas, the dualized type of design with four, and sometimes six, traffic lanes with grade separation structures to eliminate cross traffic is usually required to meet the volume demand. In rare cases, an eight-lane dual-dual design, such as was recently completed in New Jersey, is required.

In rural, sparsely settled areas the two-lane facility usually accommodates the traffic satisfactorily, but in many cases, the design should envisage future expansion. In these cases the initial two lanes are located off-center of an adequately wide right-of-way so that two additional lanes, separated from the initial roadway by a median strip, may be added. It is important that state highways be located with careful regard to modern geometric principle, recognizing the speed potential of the motor car so that location and grades will be

permanent, and future relocation avoided. Relocation, in addition to waste in physical investment, occasions a severe economic loss in tax ratables and disrupts community, business and industry.

Highway location and stability intimately affect both present and future prosperity of the region a highway traverses. Inadequate right-of-way width causes an economic loss when widening operations become necessary. Often it is impossible to widen such highways when extensive development has taken place along their borders. This situation increases economic loss because of strangling congestion from inadequate highway capacity.

In many cases it is desirable to bypass the small or medium sized community in order that motorists may have the advantage of higher average speeds between origin and destination, and at the same time relieve the community street-system of through-traffic, making room for local vehicles so that shopping and business will not depreciate. When bypasses are used, adequate and convenient connections to the community's street-system should be provided.

Because ordinary state highways are also land-service highways with free access permitted adjacent property owners, an undesirable ribbon development often takes place in rapidly developing areas. This development reduces transportation efficiency and increases the accident potential. Inadequate and uniform local zoning and planning have usually invited this misuse of the highway. The possibility of such misuse must be recognized realistically. It often indicates the desirability of using the controlled access type of highway through areas subject to potential future development.

In considering traffic problems in urban areas where streets and highways frequently cross, it is recognized that the "at-grade" land service type of highway cannot carry large volumes of traffic expeditiously and safely, particularly when cross traffic exceeds moderate proportions. It is recognized also that the controlled access express (freeway and parkway) type of highway offers the effective and permanent solution.

With complete denial of access, except at traffic interchanges and with the separation of all grade crossings, traffic can flow freely and safely without the throttling effect of cross traffic, left turns, U-turns, and red lights, thus saving much time. The use of a median zone to

separate opposite-direction traffic minimizes head-on collisions and headlight glare. At the same time, it provides more restful driving conditions with less strain.

Such modern transportation facilities are free from the hazards and frictions of roadside development. These frictions destroy transportation efficiency and unduly add to traffic hazards. The freeway and parkway restore facility of movement and handle immense traffic loads without congestion. They are capable of handling five to ten times as much traffic as a downtown business street. This type of design is the answer to today's and tomorrow's traffic problems in urban or congested areas.

In the Interest of the Many

It may be argued that the principle of restricted access and grade separation violates the rights of the individual. True, some hardship is worked on the few for the benefit of the whole. American democracy is based on this principle. That an adjacent property owner has an inherent right of direct access to the public highway is an idea that developed when roads were used for access rather than for transportation. In addition the property owner contributed all of the means for its construction, either in land taxes or in personal labor. Today the situation is entirely different. *Transportation* requirements on main arteries are predominant, and money for highway construction comes largely from the road-user, not the land-owner. Inconvenience of the few must give way to public needs.

In practice these inconveniences are usually minor. The idea of through non-stop service between origin and destination is not new. Railways operate on this principle. It is unthinkable that they should operate on the basis of the train's stopping at every cross-road and street to permit vehicular traffic. In the public interest, a sacrifice had to be made so that railways could furnish expeditious, dependable service.

Urban areas of America came into being and developed during the horse and buggy-railway economy when highway transportation was geared to animal power. This poses the particularly difficult problem of how to adjust the highway net without constricting the

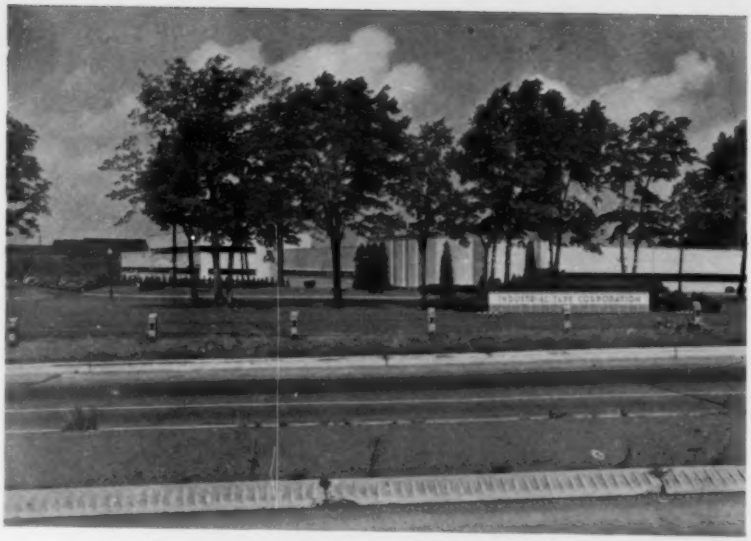

FIG. 1. Modern industrial plant.

FIG. 2. Dual-dual lane service grade separated state highway in New Jersey.

FIG. 3. Parking facilities for the workers are a part of every industrial plant.

FIG. 4. The benefits of the automotive age have little meaning for the adults and children who live here.

community by loss of taxes and useable areas. But if cities are to be rejuvenated and geared to the possibilities of the automotive age, it will be necessary to restore facility of automotive movement and provide for a greatly enlarged traffic capacity. The judicious planning and construction of an economic system of freeways and parkways offer the only answer.

Locating Urban Expressways

The location of express type facilities, therefore, presents a grave problem. It is essential that the best engineering skill and judgment be applied, particularly in the more heavily built up and industrialized areas. It is important that all available engineering techniques are brought to bear on the problem. And of these techniques, the origin-and-destination survey is a potent tool. It is necessary to provide sufficient traffic capacity in the new arteries, and to locate arteries along paths desired by the motorist and close to destinations, with due regard to available or potential parking facilities.

In some instances, it is possible to combine slum clearance with the construction of new traffic arteries. But the desire for such clearance should not locate the highway disadvantageously for traffic. Nor should it sacrifice acceptable geometric design. Possibly no other highway location problem requires so much engineering skill, study and time as the location of an expressway in urban areas. In the location of the highway and traffic interchange facilities, the ability of the street system to carry the traffic in the terminal areas is fundamental.

Plans for the future city, the location of population and industry, the efficient use of the land are important contributing considerations. In developing of a freeway and parkway system in urban areas it is often wise to carry appreciable flows of through-traffic around the congested areas with express belt-lines or by-passes, and to provide the "in city" expressways for the sole purpose of handling traffic destined for the heart of the city itself and for local movement. Only in this way can sufficient capacity be provided in areas subject to heavy traffic.

Leaven in the Dough

On the proper planning, location and design of the freeway or parkway depend the future development and prosperity of city, and state, and of commercial and industrial life in the community. This places a great burden of responsibility on the highway engineering profession for the influence of these important facilities will mould the community of today and tomorrow.

The mileage of the express type highway will constitute only a small percentage of the total road mileage in America. But it is an important mileage. It will carry a significantly large proportion of the traffic in the areas it serves. It is the leaven in the dough constituting the difference between meeting the challenge of the automotive age or allowing the automotive revolution to master and overwhelm us.

Essentiality of the highway transportation system to the modern American way of life has been developed. The impact of the automotive era on this way of life has been demonstrated and the necessity for careful and wise system planning and highway location has been emphasized.

Responsibility for meeting the challenge of the automotive revolution and of making full use of benefits that can flow from the automotive age is not borne by the engineer alone. It extends through all levels of government from top to bottom and to administrative, political, industrial, commercial and civic leaders throughout the nation.

The shackles of statics must be thrown off. The nation must be geared to dynamic wheels of an automotive era.

Traffic Noise

PETER KYROPOULOS

Dr. Kyropoulos is in charge of the Mechanical Engineering Laboratory of the California Institute of Technology. Originally the author's interest in traffic engineering was primarily from the automotive engineer's point of view. The present article is based upon part of a dissertation prepared in partial fulfillment of the requirements for a Ph.D. degree.

SUPERHIGHWAY and parkway are the two accepted means of handling the large volume of traffic encountered today and expected in the future.

Metropolitan areas are planning extensive developments of systems of interregional, state regional and metropolitan parkways and highways in order to handle the ever-increasing volume of motor traffic. As an example (Figure 1) shows the past and predicted growth of automobile registration in Los Angeles County (Reference 1).[1] In that area, the planned mileages for railways and parkways are as follows:

U. S. Interregional System	118.3 miles
State Regional System	205.1 "
Metropolitan System	289.9 "
Total	613.3 miles

A single lane of parkway is designed to carry 1500 cars an hour at an average speed of 35–40 miles an hour, compared with 500 to 700 cars an hour at an average speed of 15 to 20 mph for the typical street traffic lane.

The considerable noise produced by this amount of traffic may constitute a serious nuisance. For noise reduces human efficiency. This has been scientifically demonstrated.[2] Noise and noise control, therefore, present an engineering problem.

[1] Numbers in parenthesis refer to list of references at the end of the report.

[2] "City Noise" by Noise Abatement Commission, Department of Health, City of New York, 1930.

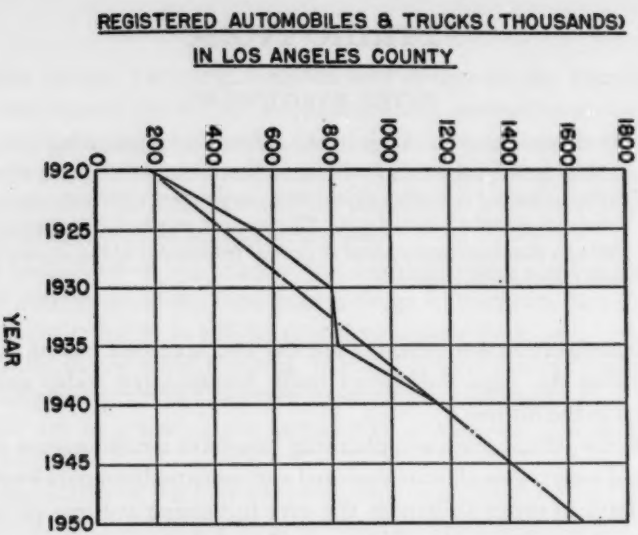

FIG. 1. Past and predicted increase in automobiles and trucks registered in Los Angeles County.

Detailed experiments leave little doubt that noise increases fatigue, no matter what the source of the noise or the type of occupation. Results reported by the Noise Abatement Commission of New York City's Department of Health had to do with room noise on typists. They illustrate the effect of noise on human beings. Principal findings were these:

The body metabolism of typists was 19 per cent more when they worked in noisy surroundings than when they worked under quiet conditions. One test-task was performed 7 and 4/10 per cent more quickly when the noise was cut in half. This shows that a reasonable reduction of noise saved 19 per cent in physical energy and 7 and 4/10 per cent in speed.

Noise level surveys have repeatedly been made in large cities (Reference 3 and 4). But only in recent years has the measuring technique been simplified sufficiently to make noise-level studies on a larger scale practicable. The measuring device reported on in Reference 3 required a truck full of equipment. At present the *Sound* meter commercially available (Reference 5) is the size of a

FIG. 2. General radio sound level meter.

FIG. 3. Sound level meter being used to measure traffic noise.

small suitcase and weighs 22 pounds (Figure 2). The sound-*level* meter consists essentially of a microphone, amplifier and output meter. Figure 3 shows the meter being used to measure traffic noise.

Definitions and Measuring Technique

Physically a sound is a pressure wave in an elastic medium. Physiologically a sound is the sensation produced through the ear.

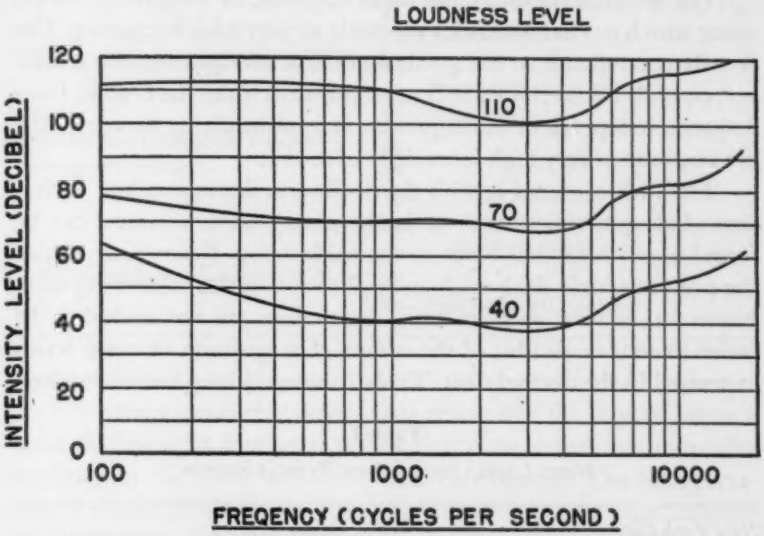

FIG. 4. Contours of equal loudness for the average ear vs. frequency (Fletcher-Munson Curves).

In order to evaluate the nuisance value of noises, a measurement of sound pressure is insufficient since sensitivity of the ear depends upon the frequency of the sound or noise. This variation of sensitivity with frequency has been determined experimentally, and the instrument is made to conform to this response of the ear.

The results thus obtained give a fair approximation to the true sensation produced by a noise. Figure 4 shows the relation thus obtained. The ordinates are "intensity level," i.e., actual sound intensity. Frequency is plotted as *abscissa*.

A frequency of 1000 cycles a second is chosen as standard. The subjective ear response is plotted from this point to the left and right. Any one curve represents a line along which the ear reports equal loudness. We observe that the sensitivity of the ear increases with frequency up to a maximum around 3000 cycles. For example, a sound with frequency of 1000 cycles a second and an intensity of 40 decibel and a sound of 1000 cycles a second and an intensity of 63 decibel sound alike to the ear.

The sound-level meter has three response, or weighting, curves along which its characteristics are made to vary with frequency. The A-scale corresponds to the 40-decibel curve of Figure 4; the B-scale corresponds to the 70-decibel curve. A fourth scale, the C-scale, has a response independent of frequency. It approximates, however, the ear response at very high intensities of sound.

The unit of sound level is the decibel. A discussion and derivation of all quantities involved in the measurment of sound can be found in any reference book on the subject, e.g. Reference 5. Since the present article deals with an application of the measuring technique rather than with its basis, derivations are not included. In order to convey an idea of the orders of magnitude of noise levels expressed in the decibel unit, Table I shows a list of familiar noises.

Table I

NOISE LEVELS (DECIBEL) OF TYPICAL SOUNDS

New York City		*Other Sources*
	102	Motorcycle without muffler
	97	Boiler factory
Subway station (express passing)	95	
	92	Automobile horn
	89	Motorcycle with poor muffler
	82	Max. traffic, Potsdamer Platz, Berlin
	80	Subway (Berlin)
	80	Very loud radio in home
	75	Motorcycle with average muffler
Noisiest non-residential bldg.	74	
	70	Very noisy typewriter room
		Very noisy restaurant

Table I *(continued)*

New York City		*Other Sources*
Average of 6 factories	68	Streetcar (Berlin)
	64	Horse carriage, noisy automobile
	59	Loud conversation, many people
	57	Noisy department store or office
Average non-residential location	51	
	50	Moderate restaurant clatter
	47	Average office, lowest, Potsd, Plat 2, Berlin
Noisiest residence measured in N.Y.	45	
	40	Very quiet radio at home
	37	Quiet office
Quietest non-residential location	33	
Average residence	32	
	27	Country residence
	25	County, Court, Chicago, empty, windows closed
Quietest residence measured in N.Y.	22	
	20	Quiet garden, London

Summarizing we may now say:

We have a measuring device that reacts like the human ear to a noise. At first sight, it appears as though it were an easy matter to take readings on the meter and draw valid conclusions. The interpretation of results, however, requires good judgment and a knowledge of the limitations of the method. This interpretation is the main problem confronting the traffic engineer, whether he is interested in planning, legislation, or enforcement.

The ultimate objective of a noise survey, is noise reduction and, where possible, elimination.

Phases for the Traffic Engineer

The traffic engineer is concerned with the noise produced by users of streets and highways. Noise from other sources, such as railroads and industries, are beyond his control. They, nevertheless, must be considered, since they constitute the so-called noise background.

Wherever the background noise is of the same order of magnitude as the vehicle noise, nothing is gained by eliminating the noise of the vehicle.

Two phases of the problem can be separated:

(1) The noise produced by a mass of composite traffic, and the determination of avoidable and objectionable sounds of noise.

(2) Comparative study of noise produced by a vehicle, and the effect of changes in design or installation on the noise produced.

Under this category fall studies of signal horns, mufflers and tire noise.

It is clear that (1) and (2) are not independent. A detailed study as indicated under (2) usually follows the determination of individual sources of noise under (1).

Vehicle noise has been investigated and is of constant concern to the motor car designer since it is intimately related to passenger comfort. Detailed data are presented in (Ref. 6, 7, 8, 9). Great progress has been made in this field during the last twenty years.

Automobile noise is due to the following sources:

1. Engine exhaust
2. Engine clatter
3. Tire noise
4. Body squeaks and rattles
5. Horns
6. Brakes

The hissing of air as it passes over window wings and fenders is heard at high speeds only and only by the passengers.

Engine exhaust commonly ranks first in importance. Control of this noise is universally attempted by legislation. Strict enforcement, however, is rare. Most motor vehicles are equipped with adequate silencing devices when they leave the factory but natural deterioration or deliberate changes in the exhaust system are common. As a result, it can be observed that a motor scooter may produce as much noise as a truck. Drivers grossly overestimate the effect of silencers.

Table II shows typical vehicle noises for comparison, observed in Pasadena, California.

Table II

Gasoline truck and trailer, loaded, uphill	103
Motor scooter, same location	100
Dump truck, loaded, accelerating on level in low gear	100
Streetcar, braking, level	94
Streetcar, starting, level	86
Diesel bus, starting, level	86
Diesel bus, braking, level	86
Passenger car (V-8) accelerating	86
Passenger car (well used) idling at curb	75

How Noise Data Are Obtained

It must be realized to begin with that a large volume of data is necessary. A noise survey is, therefore, a tedious business, and it is necessary to use data obtained for future computations.*

The B-scale (sound level 70 db) is the one closest to the average traffic noise and can therefore be used most of the time. In case of doubt, readings may be taken on all scales and the decision made later as to which one is most representative.

After a measuring site has been picked, the meter is placed and the range selector (marked 30 to 130 decibels, see Figure 2) turned from high to low values until the meter needle registers. Selector settings and meter readings are to be added.

While a stream of traffic passes the meter, the needle fluctuates more or less violently. Averaging by eye is difficult. It is easier to observe, say, over a one minute period, the highest and lowest reading and note down both.

The result of such procedure is shown in Figure 5. Readings taken along Colorado Street, Pasadena, California, were plotted against station in miles, B-scale, maximum and minimum readings for one-minute periods. It will be seen that both curves are similar. It is, therefore, possible to average both values and report the average only. It may also be reasoned that the maximum noise is the most

* Or *extrapolation* as mathematicians term the process of determining the unknown by calculation based on the known.

objectionable and should be given preference. The writer prefers the average for the following reason:

Table I shows typical noises, e.g. 97 db in a boiler factory. This represents a continuous noise of this magnitude, whereas the value of 97 db in Figure 5 (at Hill Avenue) represents a value occurring for

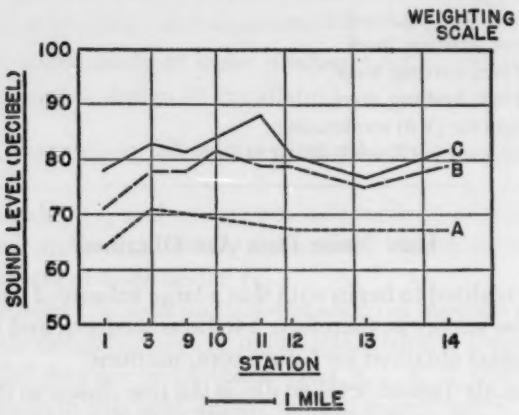

FIG. 5. Typical plot of traffic noise vs. test station for the main business street of Pasadena, California. Readings with all three weighting curves are shown (for test station key see Table III).

only a brief period. Reporting the maximum only would convey the impression that the intersection is extremely noisy, which it is not, judging by the impression the observer gets.

The preceding example shows how the judgment of the observer enters.

This judgment also enters in the selection of the test site. It was found that readings were most consistent and subjectively reasonable if the meter was placed near the curb, preferably somewhat elevated e.g. on a mail box, or held as shown in Figure 3.

Readings will differ depending on the surroundings, e.g. whether the test station is between the traffic and a building, or a vacant lot or driveway.

When measuring at an intersection with controlled signals, only traffic flowing in one street should be measured. In many cases traffic

density on intersecting streets is vastly different. This affects the readings. In obtaining data for this report, one-minute periods were selected, such as when the traffic was flowing freely, i.e. neither starting, stopping or stopped at a signal. The cross-traffic is not included.

After data have been obtained, they may be plotted in different ways.

Figure 5 shows a plot of noise level vs. test station. It also shows the differences between readings taken with A, B and C weighting scale.

Table III

KEY TO TEST STATIONS, FIGURES 5, 6, 10.

Station No.	1	Orange Grove Ave.—Quiet residential.
	2	Fair Oaks Ave.—Business section, heavy cross traffic, street cars.
	3	Raymond Ave.—Business section, moderate cross traffic.
	4	Parkway—Business section, cross traffic.
	5	Marengo Ave.—Business section, moderate cross traffic.
	6	Garfield Ave.—Business section, moderate cross traffic.
	7	Los Robles Ave.—Business section, heavy cross traffic.
	8	Vroman's Bookstore—center of block, no signal.
	9	Oakland Ave.—Business section, little cross traffic.
	10	Lake Ave.—Business section, heavy cross traffic
	11	Hill Ave.—Part business, residential and public buildings, cross traffic
	12	Allen Avenue—Business, no streetcar, cross traffic.
	13	San Gabriel Blvd.—Business, heavy cross traffic.
	14	Rosemead Blvd.—Business, very wide (divided Highway) multiple signals, moderate cross traffic.

Figure 6 shows a similar plot, including, however, a traffic count. A simultaneous traffic count is necessary if the data are to be conclusive.

Using the same data, Figure 7 was plotted to show the variation of traffic noise with traffic density. It is seen that the average

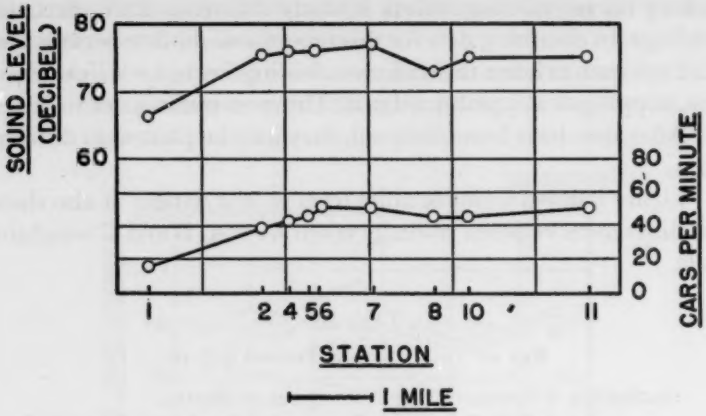

FIG. 6. Sound level and traffic count vs. test station (for test station key see Table III).

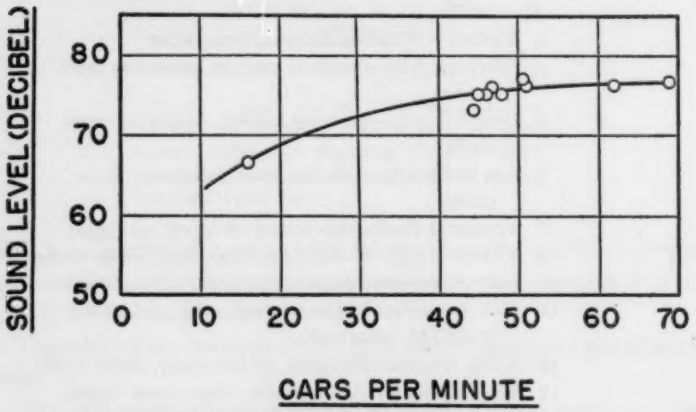

FIG. 7. Variation of traffic sound level with number of cars (data from Figure 6).

noise level remains practically constant from a traffic density of 45 cars/min up.

In comparing data, it must be kept in mind that the daily variation in traffic density greatly affects the noise. There are likewise, seasonable fluctuations, caused by weather conditions or special events such as sport seasons, etc.

Consistency of results may be judged from Figure 8 in which all data from four different groups of two observers are plotted. The mean values are the basis for Figure 6. It must be said that none of the observers had previous experience with either instrument or technique.

Figure 9 shows the variation of car noise, with car speed for an

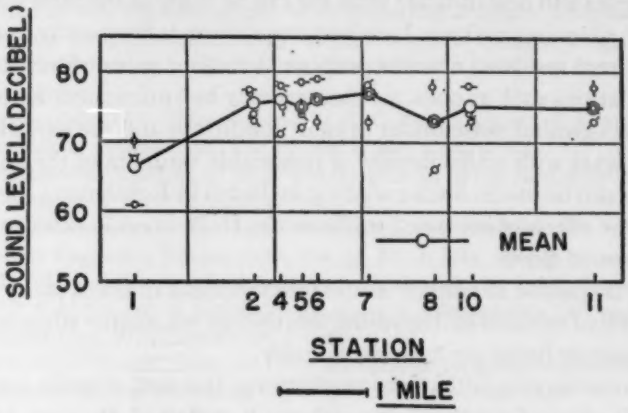

FIG. 8. Sound level vs. test station showing scatter of points obtained by different observers and on different days (for test station key see Table III).

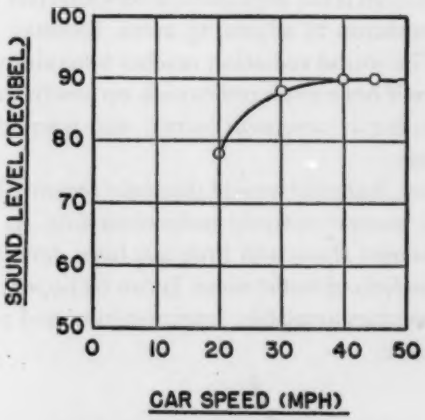

FIG. 9. Variation of car noise with speed, 1931 Chevrolet.

old car. It is seen that an increase in speed from 20 to 30 mph increases the noise markedly.

The Use of Data

After obtaining noise data, let us examine their application. Again examples will best indicate what use can be made of the information.

In planning parkway locations, opposition is frequently encountered from residents near the proposed location; or interference with installations such as open air theaters may be anticipated. Knowing the background noise under present conditions and the variation of noise level with traffic density, a reasonable estimate of the adverse effects can be made. Such a study is included in Reference 1, dealing with the effects of increased traffic on the Hollywood Parkway on the Hollywood Bowl.

It is feasible to employ sound measurement to check noise from individual vehicles to determine whether or not engine silencers are adequate or horns are excessively noisy.

In connection with parkway planning, it is well to point out that sound radiates from the source and may be reflected. Depressed highways, therefore, reflect the bulk of traffic noise upwards, especially if secondary reflection is avoided by planting on the slopes. Planting along highways, even if not depressed, is very effective in suppressing the noise transmission to adjoining areas. Elevated structures are unfavorable. The sound radiation reaches a maximum of area and the structure itself has a tendency to pick up low frequency rumbles (e.g. tire-thumping at pavement joints) and transmitting them in the surroundings.

In conclusion, it should be said that only recently have engineers and the public become actively noise-conscious. As a result, relatively little is known about and little has been done towards, measurement and analysis of traffic noise. It can be hoped, however, that as more data becomes available, interpretation and prediction will become conclusive.

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Urban Arterial Route Program in New York State

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AN URBAN area poll to ascertain the most serious problem of our times might find the international situation or some economic question leading the list. But if the survey were conducted in an urban center late on a week-day afternoon, the problems of peak-hour city travel would be far up-front in the trouble parade. Traffic and transportation headaches still make big headlines.

History illustrates how transportation advantages have affected the growth of this country and the development of its cities. If we are to continue this growth and development, new and safer facilities of greater capacity are needed to meet the demands of an increasingly mobile population. This problem is more acute in urban areas where vehicles are heavily concentrated and where outmoded streets and highways are throttling increased motor vehicle volumes.

Cities are the focal points of our industrial, commercial and cultural life. They can survive only as long as they provide these functions for themselves and for surrounding areas. Likewise agricultural and recreational sections depend upon cities for services rendered by urban centers. This interdependence is a form of our way of life. Adequate transportation between the two is an all-important life stream to be preserved.

To this end, the New York State Department of Public Works

inaugurated a comprehensive arterial route program in urban areas of the state as part of its projected overall highway program.

Careful Research and a Master Plan

The problem requires more than piecemeal projects for successful solution. The department's procedure conceives the development of a master plan of state arterial route development for each urban area. These plans are based upon all factual data relating to the community and its environs that can be secured. They are designed to meet future as well as present traffic requirements and are capable of further expansion as future conditions warrant.

The program in each community begins with basic traffic surveys to ascertain the travel pattern and principal weaknesses that produce congestion. This field work includes origin and destination surveys, and a traffic census to disclose directional movements, hourly volumes, and relative numbers of vehicles by types. Speed and delay studies determine the extent, location, and underlying causes of traffic bottlenecks.

The origin and destination survey consists of two parts: the external and the internal survey. After an examination of the street pattern of the particular community and of features affecting the normal and peak-hour traffic movements, a plan is laid out to establish a cordon that will intercept the inbound motorist on all primary thoroughfares both at the city limits and around the central business area. In New York State surveys, return postal cards are being used. The simplicity of this method permits available manpower in the department to undertake a greater number of projects within a scheduled period.

Further Methods for Getting Data

Prior to the survey the city is divided into zones of origin and destination. These are related to the land use pattern, major thoroughfares, census tracts and to the geographical features of the community. Our return postal cards have undergone refinements in order to arrive

at a form that will produce the maximum amount of dependable information with a minimum of inconvenience to the motorist.

The manning of stations has presented a problem not only for the Department, but also in the matter of providing proper police regulation. It is to the credit of the district offices, the state and local police, that little or no congestion and no accidents developed at the survey stations in the forty-eight cities covered in 1946 and 1947.

Public reaction to the survey has been favorable. This indicates the widespread interest in the urban area program and a pronounced desire to assist in obtaining early relief from difficult local traffic conditions. The courteous and businesslike attitude shown by the personnel engaged on the surveys has reflected favorably upon the department. It has encouraged public cooperation.

The vehicle volume count is an important element in the fact-finding surveys. Alone it does not disclose adequate information for the development of an overall plan. But as a component part of the total information, it is essential in expanding the percentage origin and destination data to the total volume and to disclose the general pattern of traffic movement by type. In addition, it establishes a relationship between the average hour, peak-hour and twelve-hour movements on thoroughfares.

Maps Show Zig-Zag Trips

Following the tabulation of field survey information, data on origins and destinations, expanded to total volumes, are plotted to show the desire-lines of travel from zone to zone within the urban area, area movements to and from outside regional zones, and through area movements. These maps show visually the maze of zig-zag trips across and through the municipality and the extent to which the bulk of travel is directed into the central business district. The relative importance of the primary traffic generators is made evident by the various origin and destination charts.

This information, though quite comprehensive, is not sufficient for the design of an adequate highway system for future requirements until the future growth of the area has been considered. The growth of an area as related to this type of study is not confined to

population; it takes into account also the expansion of industry, commerce and residential use, and the expected increase in motor vehicle registration. The period of projection adopted for New York State surveys extends to 1960. This period can be considered, it was believed, as the conservative forseeable future in the field of traffic study and analysis.

The basic problem the department is attempting to solve is the safe and economical movement of people and goods from points of origin to points of destination, in conformity with a sound plan of thoroughfare design in harmony with an acceptable land-use pattern. Data indicate the general lines of travel desired and the relative volumes of traffic involved. These data, when further expanded to the volumes anticipated in the period of forecast, form the basis of estimate for new facilities required to meet the growing traffic needs.

Getting Space Relationships

The speed and delay studies form another important element of the planning process. The purpose of these surveys is data on time losses and on causes of delay which, when analyzed, give the time space relationship of normal and peak-hour travel over major streets of present systems. This study measures the efficiency of present street traffic operations.

In conducting the forty-eight city traffic surveys completed in 1946 and 1947, more than 7,500,000 vehicles were counted and 760,000 postal cards were given out. About 35 per cent of these cards have been returned to district offices. Less than 2 per cent of the returned cards were improperly filled in, or contained inadequate information.

These favorable results are largely credited to the urban area publicity that preceded the issuing of cards. The public was informed of the time, method and purpose of the survey and their cooperation in returning cards promptly was urged. This phase of the program was developed by the Department Public Relations Bureau, which prepared material for press, radio and bulletin board. The manner and extent to which the scheduled releases were used had a direct bearing upon the response from drivers.

Five thousand two hundred department employes were used at different times in connection with this work. A total of 600 state police and 1,000 local police regulated traffic at the survey stations with the result that little or no delays were encountered and no accidents occurred.

The total cost of these surveys, including mechanical tabulation, averaged about 5 cents for each person.

In New York State there are sixty-one urban areas varying in size from about 10,000 persons to over a million, exclusive of the New York City area.

Little Planning Yet In Small Cities

The development of master plans of arterial routes for these areas is a herculean task. In New York City only has the planning of such routes sufficiently advanced that both state and local officials can agree on the appropriateness of the proposed system and adopt the local master plan without prolonged study.

In other metropolitan sections complete arterial route studies are necessary. In many instances, local planning emphasis has been directed at other objectives. In most of the smaller cities, no local planning of any sort has been undertaken.

To make the problem still more difficult, the training of the department's designing staff has been directed toward the development of primary inter-urban state highways and routes of lesser importance. City arterial route planning, and even construction, is a new field.

In order to overcome this difficulty, a Bureau of Arterial Route Planning was created in the department. This new bureau is designed to act as a consulting agency to work with the district engineers in each of the public works department districts.

The bureau organization is headed by a Director of Arterial Route Planning, who is directly responsible to the Chief Engineer of the Department. Three principal engineers in charge of planning serve under the Director in carrying out the functions of the bureau. They in turn have a complement of specialists in various fields such as traffic and planning, design and valuation. Within the bureau there is also a special group trained in developing art renderings and

popular ways of presenting the statistical and other basic material upon which the plan is based.

Spade Work and Organization

The spade work, however, is done in the district offices. Each district engineer has the responsibility for the preparation of the master plan and for the collection and analysis of all basic material for urban areas within his jurisdiction. It is during the course of this work that the bureau consults with the district offices. When the plan is completed but before the final report is prepared for submission to the local officials for their review, a final inspection of the plan in the field is made by the Superintendent of the Department and his entire staff of advisers.

This procedure has been successful in New York. Since 1945, final reports have been submitted to Buffalo, Dunkirk, Rochester, Syracuse and Rome. The first two have been approved and actual construction is under way in Dunkirk. Bids will be received at an early date for a major project in Buffalo, and others will follow in the near future. When local approval of the Rochester, Syracuse and Rome plans, submitted to the local authorities in September, is received, actual construction in these cities will be promptly undertaken. Plans for five other cities will be ready for local presentation before the end of the year. The department has nineteen master plans of city arterial routes now on the drafting boards, and forty-eight city traffic surveys have been completed since 1945.

The basic arterial principle of safe and expeditious movement of passenger, transit and commercial vehicles already stated calls for free-flowing traffic, using adequate traffic lanes with a minimum of interference by cross or entering traffic. Where the anticipated traffic volume warrants, plans provide for an express type of highway with grade separations and interchanges. The standards of design contemplate that the completed new construction will adequately provide for the needs of modern traffic.

In general, lanes for moving vehicles are designed a minimum of twelve feet wide, and parking lanes are established eight feet wide. It is planned that where right-of-way can be obtained at a cost com-

mensurate with the type of improvement, directional movement will be separated by substantial malls. Where the facility is designed for a combination of through and local traffic, controlled access points are incorporated in the design to meet the local conditions. In addition to the objective of greater traffic capacity, it is essential that safety be built into new arterial highways.

Reports Already Made to Cities

The broad scope of the urban planning program is illustrated by comprehensive reports prepared and presented to local authorities. For example, the recent report to the city of Rochester totals over 175 pages with 53 plates, charts and graphs, covering the important phases of the social and economic features of the area in addition to the complete traffic study. Major traffic improvements are illustrated on aerial photographs by artists' renderings which supplement the extensive details of the plan presented in colored strip-map form. The submitted program within the city proper is estimated to cost $34,000,000, based upon equalized 1940 construction prices and land values plus 15 per cent. The planned routes in the urban area, but outside of the city, are estimated to cost $6,500,000 more. The proposal calls for 28.8 miles of new routes within the city and 19 miles in the outer areas.

The report submitted to Syracuse and Onondaga officials, similar in scope to the Rochester plan, included twenty-one miles of highway projects at an estimated cost of $23,500,000, and approximately twenty-three miles of construction outside of the city but in the urban area at an estimated cost of $5,000,000.

These urban area programs, with counterparts in reports to Buffalo, Dunkirk and Rome officials, will be followed successively by scheduled reports for all New York State cities.

Parking Also Must Be Solved

In considering the local traffic problems, regard has been given to the importance of facilities at the ends of arterial routes leading into the central district and other congested areas. These new highways

FIG. 1. Proposed Erie Boulevard Expressway, City of Syracuse.

FIG. 2. Proposed intersection of Clinton Avenue Expressway and Inner Loop in vicinity of N.Y.C.R.R. Station Plaza, City of Rochester.

proposed for urban areas will not be able to develop maximum benefit unless terminal facilities are built to meet the anticipated increases in motor vehicle volume.

Parking affects every citizen of a community. The merchant is interested in his sales volume; the owner is interested in the stability of his property value. The shopper is concerned with convenience in making his purchase, and the downtown employee is desirous of having a convenient place to park his personal means of transportation.

The solution to this problem seems to rest primarily with local enterprise, with local governments providing official leadership. The responsibility of the state is limited to the stimulation of local action and to enabling legislation where needed.

The Urban Area Reports emphasize the importance of this problem, and point out that the full benefit of proposed arterial routes cannot be derived from their construction until some adequate solution to the parking problem is likewise accomplished.

Master plans have been prepared to meet anticipated traffic requirements fifteen years after the date of the traffic survey. This period was chosen because it was believed to be about the maximum period for which a reasonably accurate forecast with so many influencing factors could be made. In addition, it seemed to fit into a reasonable financial program.

When the 1945 legislature, on the recommendation of Governor Thomas Dewey, authorized the department for the first time in its history to plan and construct a state system of urban arterial routes for each city in the state, as funds were made available, it opened up a new era in state and city cooperation. This action was taken in recognition of the ever-increasing volume of inter-urban and regional state traffic that either originates or terminates within, or flows through, those metropolitan sections. Between 80 and 85 per cent of the traffic on our state highway system in those areas is of that character.

Maintaining and expanding the facilities necessary to support that traffic within cities has become—or is rapidly becoming—an impossible burden to the city taxpayer. The arterial route legislation was passed in order to lift most of the load resulting from state traffic

from his shoulders and at the same time enable him to secure the indirect benefits which spring from the creation of a fully adequate arterial system and which are almost always of parallel importance. That and the comparable federal legislation are master strides in highway progress.

Who Pays and How?

In New York State, the state meets the entire cost of construction, and one-half the cost of right of way. The only cost to the local government is for the other half of the right of way.

Continued federal aid for urban highway construction, coupled with the anticipated state program, reasonably indicates that most of the arterial plans can be completed within the fifteen-year period of forecast. The entire system, therefore, could be constructed in sufficient time to observe its performance and other controlling factors before advancing another plan for supplementing and extending the system, if required.

It is believed that by following these general principles the urban arterial route challenge now confronting the New York State Department of Public Works can be successfully met.

The immediate value of the completed arterial route system will be reflected in the saving resulting from improved traffic patterns, elimination of congestion, time saved in travel and reduction in injury and damage due to vehicle accidents. Broader benefits will accrue in the form of the provision of a base for further local planning processes in the development of land use, neighborhood development, recreational areas and other elements of an over-all city plan.

The final result of the Urban Area Arterial Program promises to be one of great benefit to cities in New York State.

Combating Winter Accidents

DONALD S. BERRY

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DRIVING hazards at any season are coming to be recognized by nearly every driver and pedestrian. But added hazards of winter driving are often overlooked or recognized too late. During the past eight years, motor vehicle mileage death-rates in northern United States have been from 24 to 53 per cent higher during winter months than in summer.

As shown in the attached chart (Figure 1), the 1946 nation-wide

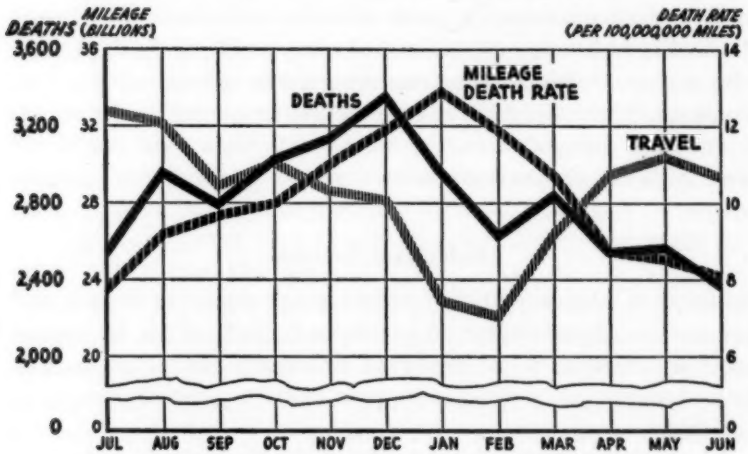


FIG. 1. 1946 monthly deaths mileage and mileage deathrate.

mileage death rate reached its peak in January. The rate is greatest in late fall and winter months, and the lowest in spring and summer.

The two major factors in winter driving's added hazard in all sections of the country are *inadequate traction* and *reduced visibility.*

Longer hours of darkness during winter months contribute substantially to higher death rates. The average number of pedestrians killed per month between 6 and 7 P.M. in November, December and January is four times the average number killed per month in the same hour of the other nine months.[1] During November to January, this hour is either dusk or darkness. It is a daylight hour the rest of the year. Three out of five fatal accidents occurred at night during 1946. While darkness has a lot to do with the increase in pedestrian death rates, non-pedestrian deaths also show the influence of hours of darkness.

Wintertime also reduces visibility, through inclement weather conditions. Snow, sleet storms, fog, mist, rain, and obstructions to driver vision from frost-ice-or-snow-covered windshields and snow banks contribute significantly to the accident toll. Under present traffic volumes and speeds, good visibility is of prime importance. Lack of it, without doubt, has caused many accidents. In 1946, some obstruction to driver vision was reported in one out of five fatal accidents. About two-fifths of the obscurements were on the vehicle itself—rain, snow, sleet on the windshield. More than one-fourth were highway obstructions, such as streets, buildings or embankments.

Inadequate Traction

Inadequate traction on road surfaces is due primarily to snow and ice, and, to a lesser degree, to wet surfaces, particularly for certain types of pavement. When combined with faulty driving practices or lack of winter safety equipment, poor traction generally results in skidding.

A special study made by the Council's Committee on Winter Driving Hazards a year ago in four typical snow-belt states (Connecticut, Indiana, Minnesota and Wisconsin), showed that approximately *two-thirds* of the total number of traffic accidents occurring during the winter months (December 1945, January and

[1] 1947 Accident Facts.

February 1946) occurred on snowy and icy surfaces. The percentage figures for rural and urban accidents were almost the same, indicating that snow and ice have about the same effect on accident rates whether on city streets or on rural highways.

Even more important is the relation of snow and ice to fatal accidents. For the four states included in the study, from 30 to 55 per cent of all fatal winter accidents took place on snowy and icy surfaces. This study further disclosed that a disproportionately high number of accidents occur on county and local roads under snowy and icy conditions, indicating that these roads should receive a relatively greater share of winter maintenance than has been customary.

Winter Traction Tests

Recognizing the added hazards of winter driving, the National Safety Council's Traffic Section appointed the Committee on Winter Driving Hazards in February, 1939, to make a thorough investigation of dangers peculiar to winter driving. Under the chairmanship of Prof. Ralph A. Moyer of Iowa State College, the Committee now has conducted four research projects, the first of these being the preliminary traction and skidding tests conducted in March, 1939 on the frozen surface of Lake Calhoun in Minneapolis, Minnesota. More thorough and comprehensive tests were conducted in February, 1940 on frozen Lake Cadillac, Cadillac, Michigan. Results of this test project were presented in the 1940 Committee report entitled "Safe Winter Driving."

In January, 1946, further tests, primarily with heavy trucks, were made at Houghton Lake, Michigan. A fourth research project was conducted last winter on Pine Lake and nearby roads and streets in Clintonville, Wisconsin. A summary of results of these last two test projects is presented in the 1947 Committee report entitled "Winter Accident Prevention."

TEST RESULTS

Perhaps the most striking fact revealed by these researches was the surprisingly wide variation in performance with bare tires on

smooth ice. Braking distances from 20 mph on smooth ice range from a low average of 110 feet to a high average of 250 feet, depending upon the ice condition, and to a lesser extent on the type of vehicle. Acceleration and cornering performance likewise vary, but to a lesser degree. Thus the real hazard of driving on snow and ice is due to the extreme variability and unpredictability of the surface condition.

Figure 2 shows the tremendous range in glare ice braking distances, even with one vehicle. In general, "wet" ice (at temperatures

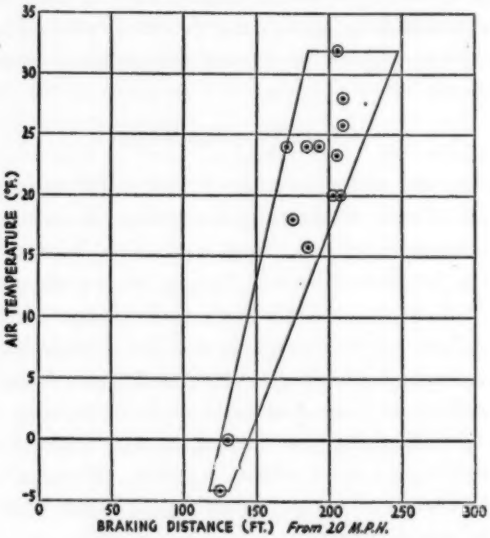


FIG. 2. Braking distance vs. temperature on lake ice. Vehicle-passenger car, synthetic tires. Each plotted point represents the average of a series of runs.

most frequently encountered in the upper temperature ranges after a freezing rain or sleet storm) is twice as slippery as "dry" ice (encountered at the low temperatures). While data presented in this chart indicate a definite trend, a closer study reveals that it is impossible to deduce any direct mathematical relationship between braking distance and temperature. Even at one temperature, e.g., 20°, braking distances with this one vehicle varied from 165 ft. to 210 ft.

Apparently there are many factors other than temperature—whether it is sunny or cloudy, the relative humidity, wind velocity, the time elapsed since the ice was shaved, and possibly others, that play an important part in determining the relative "slipperiness" of the ice surface. Whether tests are run on freshly shaved ice, or on ice that has been shaved and then allowed to glaze over from several hours exposure to the sun has an important bearing on the situation.

From the above, as well as from general observation, it may be concluded that every driver operating under actual road ice conditions should expect to encounter even wider variations in performance and should be equipped accordingly. The hazard inherent in snowy and icy surfaces can best be visualized by realizing that braking distances on snow and ice are three to twelve times that required on dry pavements.

Another striking fact revealed by these test projects is the effectiveness of tire chains in reducing braking distances and increasing traction. Under slippery snow and ice conditions, tire chains reduce passenger car braking distances about 40 to 50 per cent, as compared with braking distances possible with bare tires. They also provide added traction often essential for getting underway or climbing a grade. Their use on icy and snowy pavements is recommended both to provide added traction and to reduce braking distances.

Tire chains are essential on trucks and tractor-trailer equipment operating over snowy and icy pavements. Because of the greater weight of trucks as compared to passenger cars, tire chains are even more effective. With chains on the rear wheels only, braking distances are reduced about 60 to 70 per cent.

The effectiveness of sanders in reducing braking distances was also investigated to the extent of testing four different types of grits. Using the customary locked wheel stops, braking distances were actually increased slightly with three of the grits, while the best grit reduced braking distances only 10 per cent. Sanders were most effective when the driver pumped the brakes and geared down. Using this procedure, the best grit reduced braking distances from 30 to 42 per cent below the bare-tire locked-wheel stops, depending on whether sanders are used on the rear wheels only or on all wheels.

An approximation of the relative effectiveness of chains and sanders on snow and ice is shown in Figure 3.

The rather common practice of reducing tire pressure to increase traction was investigated through a series of passenger car braking distance tests on ice at temperatures varying from 0 to 2 degrees. These tests were run at "normal" pressures of 32 lbs., at 27 lbs., and at 22 lbs. Under these particular conditions, no significant difference in braking ability was apparent.

A four-wheel drive truck demonstrated a marked advantage in accelerating ability compared with the conventional rear wheel drive truck, when the two vehicles were pitted in a series of tests. In the empty condition, the conventional model needed 11.0 seconds to accelerate through a speed range of 10 mph on glare ice, while the four-wheel drive truck took only 6.0 seconds, a reduction of 45 per cent. This approximately indicates the advantage of four-wheel drive trucks over standard trucks in climbing hills on icy roads.

Tests were also made to compare the braking ability of natural vs. synthetic rubber tires. Under comparable conditions, braking distances from 20 mph on lake ice ranged from a low average of 125 ft. to a high average of 210 ft. with the synthetic tires, compared to a range from 84 ft. to 169 ft. with the natural rubber tires. While this represents a difference in braking ability between the two types of tires ranging from 20 to 33 per cent, the extreme variability in braking distances because of different ice conditions seems to be of much greater significance than type of rubber.

A number of tests were made to determine which was most effective, "pumping" the brakes or "locking" them. In general, it was found that "pumping" reduced braking distances from 5 to 20 per cent, depending on the vehicle. Contrary to the general belief that the proper method of "pumping" is to apply the brakes in a gentle pumping action, the tests demonstrated that the shortest possible stop is obtained by a series of very rapid and hard jabs on the brake pedal, continuing until the vehicle is brought to rest, making certain that the brake is completely applied and completely released on each individual stroke. Since steering control is lost when the wheels are locked, *pumping is recommended* as the proper method of braking on ice.

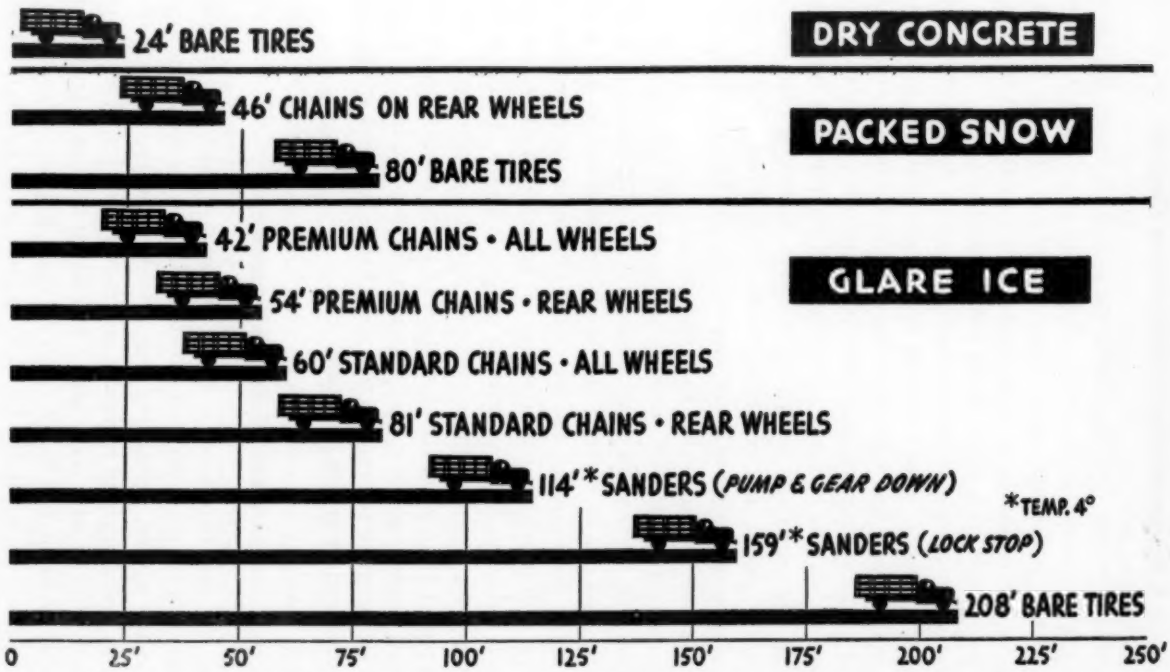


FIG. 3. Average braking distances, in feet from 20 m.p.h. vehicles—5-ton trucks, temperature 16°–28° except as noted.

A Balanced Winter-Traffic Safety Program

Unfavorable winter driving conditions present a broad problem, one of grave concern in practically all sections of the country. Road maintenance, police and other safety organizations, both in cities and states, are called upon to perform many activities to facilitate traffic movement with safety under these conditions.

The fundamental activities include informing the driver regarding winter hazards, winter driving equipment and safe operating rules, maintaining safe highways through snow removal and treatment of ice, analyzing available records to determine the relative importance of various accident circumstances, engineering improvements in alignment and design of roadways, reporting road conditions to the public and enforcing traffic regulations. The proper scope of these activities will vary depending on climate, road mileage, traffic volumes and other local conditions.

An energetic and well-meaning program will fall short of its objective—the prevention of accidents and the facilitation of traffic movement—if one or more of the fundamental activities are weak or dormant. For example, the use of tire chains or the spreading of abrasives will provide added traction for vehicles on snow and ice, but their values to drivers diminish as speeds go up. Available expenditures for highway improvements may be ineffectively used unless points of accident concentration or traffic congestion are determined through accident analysis and traffic flow studies. A driver education program is most effective when backed up with an efficient and realistic enforcement program.

Winter Road Maintenance

During the past two decades, there has been an almost universal acceptance of the principle that streets and highways should be kept open in the winter, permitting year-round use of the public's tremendous investments in highways and motor vehicles. Whether or not roads choked with snow are to be cleared for use is largely an economic problem. But if such roads are open, highway departments should assume responsibility for making their use as safe as possible.

In the case of roads covered with snow but yet passable, or those covered with sleet, the same responsibility for safety exists as long as motorists insist in using facilities that are passable.

The safety problem of winter maintenance is largely one of ice control. Snow storms are dangerous because of reduced visibility, but this is a problem for the motorist and not for the maintenance crew. Snow on the roadway is not particularly hazardous as long as it is snow, but it is potentially dangerous because it so easily changes to ice with the packing action of traffic and repeated freezing and thawing. Sleet, of course, also forms ice. Snow should be removed as rapidly as it falls, therefore, and ice as soon as it has been formed. These tasks and the securing of improved traction on ice already formed are the largest part of the safety problem in winter maintenance in snow-belt states.

Maximum safety is provided, of course, when snow and ice are completely removed. The maintenance of bare pavement is the policy now rapidly being adopted by many street and highway departments. Because bare pavement maintenance is not always possible, however, many street and highway departments use abrasives on slippery surfaces. Although local availability and cost are usually controlling factors, tests have demonstrated superior tractive qualities in certain types of abrasives. Superior abrasives should be used when their extra cost can be justified from the standpoint of public safety. In the Committee's Lake Calhoun tests, chemically treated cinders were about 25 per cent more effective in reducing stopping distances than chemically treated sand.

Abrasives should be treated before spreading in order to embed them. Wind or traffic will blow off particles not anchored in the ice or snow. There are two general methods of treatment; heating, and admixture with calcium or sodium chloride. Heating has not generally been found satisfactory by most highway departments. Admixture with sodium or calcium chloride is recommended.

Treatment of icy pavements with abrasives is primarily a problem of conveying large quantities of material from storage to the road in the shortest possible time. The essential factor is speed, and to get speed, we need advance preparation. Mechanical spreading is rapidly replacing hand spreading. By the mechanical method, the

same amount of material covers a larger area more uniformly, the number of men needed on each unit is reduced, and higher operating speeds are possible. In general, mechanization should always be sought. It reduces unit cost and makes it possible to add larger portions of the highway system to the winter maintenance program.

Highway departments should make it a goal to treat the entire length of road rather than only hills, curves and intersections; at least on main trunk highways. Financial considerations of course, generally limit continuous sanding to a small percentage of total highway mileage. Therefore, where sanding of "danger spots" only is the policy, turns and curves, grade crossings, intersections, and hills, should be sanded *far enough back* from the danger point itself to permit an approach at reasonable speed and yet make it possible to stop if necessary before reaching it, if cars have stopped in the danger zone.

Fundamental Driving Rules

Safe driving rules under winter road and weather conditions are these:

1. When starting out, get the "feel" of the road by trying the brakes or "gunning" the motor—while driving slowly and when no other vehicles are near—to see how much the wheels slide in stopping or accelerating.
2. Adjust speeds to conditions. A good guide is the speed pattern of the majority of drivers. On slippery surfaces and when visibility is poor because of inclement weather or darkness, conservative speeds are imperative for safe driving. On glare ice, the recommended maximum safe speed for vehicles not equipped with tire chains is in the range of 15 to 20 miles an hour.
3. Slow down well in advance of intersections and curves. Speeds should be reduced to a point where a complete stop could be safely made on approaching an intersection. Rounding a curve under slight power of the engine will help guard against side skids.
4. Use tire chains when driving on icy and snowy road surfaces, since they are the most effective and practical form of self-help for the motorist in increasing traction. Chains are particularly helpful on heavy vehicles. Chains on all four wheels provide steering control and permit higher curve speeds. It must be

emphasized, however, that performance on snowy roads, even with chains, especially on icy roads, does not nearly equal that possible with bare tires on dry pavements. Chains should be regarded as providing an extra and needed margin of safety *at moderately slow speeds*—a margin that is thrown away if speeds are too fast.

5. Keep the windshield and windows clear of outside snow and ice and inside fog and frost at all times. Lower the side windows, if necessary, to maintain side vision.
6. Follow other vehicles at safe distances. The recommended practice is to follow other vehicles at a distance which will permit a stop or allow ample room for maneuvering out of danger if the vehicle ahead should suddenly come to a standstill. This is especially important on icy and snowy roadways where multiple collisions frequently occur because of insufficient spacing between vehicles.
7. Use an intermittent brake application. Normal application of brakes on an icy or snowy surface may lock the wheels and throw the vehicle out of control. For other than emergency stops, it is important for drivers to use their brakes sparingly and with a minimum of pressure on the foot pedal. For an ordinary stop on a slippery roadway, brakes should be applied with a light pressure of the foot until the point of skidding is impending—then released and applied again in like manner. Intermittent braking will help prevent locked wheels and consequent loss of directional control.
8. Signal the intent to turn or stop. Forewarned, the normal driver will take reasonable measures to avoid an accident. The importance of signaling becomes evident, especially when visibility is limited or when ability to stop or maneuver is restricted by a slippery roadway.

Drivers' Knowledge Concerning Winter Hazards

It is evident, from the sharp increase in skidding as road traction decreases, that drivers seriously overestimate the traction on slippery road surfaces. Skidding is generally a sign of a speed too fast for conditions.

There are several ways in which drivers overestimate traction. First, a false reliance is placed on "non-skid" tires on snow and ice. Second, many drivers have misplaced confidence that tires will give

extra traction when air pressure is reduced below normal. The Committee's tests have shown that there is no safety advantage in this reduction. Where substantial improvements in traction are effected through chains or abrasives, it is probable that some drivers overestimate the additional traction provided in the belief that they can drive almost as they would on dry roads.

Special driving skills, techniques and equipment are required for safe winter driving. It is only after an accident or a near-accident in the late fall or early winter that drivers realize the true nature of winter driving hazards. Most drivers must re-learn each year, it seems, the proper techniques and driving practices necessary for winter driving.

Let's help them!

Evaluation of Off-street Parking in Terms of Operating Time

EDMUND R. RICKER

Mr. Ricker is Research Assistant in Transportation at the Bureau of Highway Traffic at Yale University. After being graduated from the Bureau in 1941 (following three years of service with the Vermont Highway Department) he served with the U. S. Army Engineer Board, first in the development of traffic control devices and techniques, and then on devices for seeing in the dark. He is an Associate Member of ITE and a Junior Member of ASCE. The following article was prepared from results of a study of off-street parking facilities conducted by the Bureau on a grant from the Eno Foundation. The research centered on the time-motion relation between operation and design of parking lots and garages. Results will be published in a technical report of the Eno Foundation. This article introduces the report.

CURRENT widespread interest in the parking problem emphasizes the need for proper design in off-street parking facilities. Surveys of parking demand, enabling legislation, financing, and planning all point toward the same end—the construction of adequate off-street parking areas.[1]

Considerable confusion arises in considering the actual need for additional garages because many of the older garages built during the financial and automotive boom of the 1920s are not filled to capacity or have failed financially. In some cases, they have been converted to other uses. With today's intensified parking demand and high construction costs, new facilities *must* be properly located, designed and operated. "Second guesses" are too expensive.

What lessons can be drawn from older garages whose operation is characterized by slow service and low patronage? What elements have proved their value and should be applied to new designs?

[1] The study described in this paper has included both parking lots and garages. Because the operation of garages is more complex, and in order to avoid repetitious phrases, the term "garage" is used throughout, it being left to the reader to interpolate "lots" where applicable.

METHODS USED IN THIS STUDY

The design and layout of off-street parking facilities was studied from a traffic engineering approach. It has been assumed that the location and parking demand have been, or can be, determined. Although these qualifications are not readily resolved, and certainly come under the purview of a traffic engineer, it has been necessary to limit the problem in order to handle it in the time allowed.

Even though considerable literature is available on the parking problem, little of it is concerned with the actual design of off-street facilities. Certain accepted standards of stall and aisle dimensions, ceiling height, and ramp slopes have grown up and may be found in various publications. One is the American Automobile Association *Parking Manual*.[2] The most comprehensive study, however, will be found in an article in the February 1929 issue of the *Architectural Record*.[3] Although this article is "dated," it is significant because it sets forth the standards of another period of considerable garage-building activity—in which most of today's better known garages were built. Techniques and special designs in the past were kept as trade secrets by some architects and engineers; in fact, many features were patented, although most of the patents have now expired.

In this study, it was found necessary to depend heavily on the assistance and advice of parking garage operators. Field trips were made to Boston, New York, Philadelphia, Baltimore, Washington, Detroit, and Cincinnati. Detailed time-motion studies were made in a dozen garages; operation and design were observed in twenty-five others.

Garage operators and managers were, without exception, liberal in allowing access to both parking floors and records, and in offering suggestions. Appraisals and evaluation of design elements that cannot be measured directly are in large part indicative of the opinions of these men. Due to the confidential nature of the financial and operational data supplied in some instances, no specific mention of any garage is made. In most instances, time-motion data were taken

[2] "Parking Manual," American Automobile Association, Washington, 6, D. C., 1946.

[3] E. P. Goodrich, *et al*, "Garages, Standards for Design and Construction," Architectural Record, Vol. LXV, p. 178, February 1929.

with a stop-watch, while some operations peculiar to parking lots were photographed with a movie camera, the use of which is described in Technical Report No. 1 of the Bureau of Highway Traffic.[4]

DESCRIPTION OF GARAGE OPERATION

In any parking garage, there are three main steps of operation—acceptance, storage, and delivery. The following paragraphs correlate these operations with the major design features of a typical attendant parking garage. The steps described closely follow those in one of the garages studied; they may be considered typical of a modern and efficiently operated garage.

As the customer drives off the street, he passes through the *entrance* into a *reservoir space* in which cars are stored temporarily before attendants drive them to *parking floors*. The floor-man time-stamps a ticket, marks it to identify the car, places part of it under the windshield wiper and gives another part to the customer as a receipt.

As soon as an attendant is available, he drives the car up (or down) a *ramp* to the parking floor. He drives along the *aisles* to an available *stall* and backs the car into position. He then marks one part of the ticket with the number of the parking stall used, returning this to the cashier's office at the next convenient time. The other part of the ticket, he leaves under the windshield wiper to identify the car. The attendant then returns to the reservoir space for another car, traveling by the most convenient *inter-floor driver-travel means*.

The car is now stored for whatever period the customer desires. It is not moved except when located in the front row of a double bank of stalls and a rear car has to be driven out.

When the customer returns, he presents his check to the cashier, who collects a fee depending on the length of the time the car was parked, and returns part of the ticket as a release. The cashier places part of the ticket, indicating location of the car, in a box available to attendants. As soon as an attendant is free, he takes the first ("oldest") ticket in the box and goes to the parking floor indicated. After locating the car, he delivers it to the customer in the outbound

[4] Bruce D. Greenshields, et al, "Traffic Performance at Urban Intersections," Technical Report No. 1, Bureau of Highway Traffic, Yale University, New Haven, Conn., 1947.

reservoir. The customer identifies himself by his release, and drives through the *exit*.

OPERATION TIME IN TYPICAL GARAGE

In the garage previously described, time measurements were made on individual operations, with the following results:

Acceptance	
Customer driving in from street	10 sec
Issuing ticket	30 sec
Attendant getting in and starting car	8 sec
Movement on main floor	4 sec
Driving on ramp	12 sec per floor
Driving on parking floor	6 sec
Parking	18 sec
Attendant returning to main floor	40 sec
Total time, unhindered movement, about	2 min 20 sec
Total time, normal operation, about	3 min
Delivery	
Customer presenting ticket	30 sec
Cashier operation	20 sec
Attendant travel to parking floor	40 sec
Attendant travel on parking floor	25 sec
Getting in and starting car	8 sec
Driving on parking floor	6 sec
Driving on ramp	12 sec per floor
Driving on main floor	4 sec
Delivery to customer	10 sec
Customer loading	20 sec
Total time, unhindered operation, about	3 min
Total time, normal operation, about	4 min

Times shown above do not consider delays during peak hours. The difference between the "unhindered operation" and "normal operation" times are due to delays caused by the movement of several cars at once. Times shown are for one-way operation; i.e., all cars com-

ing in or going out. In an interchange of cars, the time to put away one car and deliver another will be about 50 per cent greater than either single operation, or about five minutes. The time per car per attendant is not as great as the total shown in the table, since attendants are not involved in cashier or customer-loading and unloading operations.

From the previous table, certain operations stand out as time-consuming, and hence important in the design of a garage, particularly movements of the attendant when not in a car. Other items such as ramps do not consume much of the total time.

PHYSICAL FEATURES OF PARKING GARAGES

The major space requirements in a parking garage are *reservoir space, ramps, aisles,* and *stalls.* The arrangement of these is further affected by the location of *entrances* and *exits, inter-floor driver travel means,* and *cashier's cage.* Minor space is taken up by rest rooms, waiting rooms, and so on.

It is generally accepted that *entrances* and *exits* should be located as far as possible from street intersections. The slow movement in and out of restricted openings and across pedestrian sidewalks should be removed from congestion.

The traffic pattern of adjacent streets bears directly on entrance and exit location. This takes into account the expected patronage of the garage, easy access to the largest number of patrons and the avoidance of conflict in peak movements to and from the garage with those on the street. Where one-way streets abut the location, entrance and exit should be provided for the indicated direction of travel, else unnecessary round-the-block movements will result.

Multiple lane entrances and exists are necessary to avoid delays caused by dilatory customers or mechanical breakdowns. Entrances should be clearly marked, attractively designed, and large enough to avoid giving the impression of entering a hole-in-the-wall. Exits should allow ample sight distance at sidewalk crossings. Pedestrians may be protected by an automatic bell or other warning device.

It is particularly important not to place gasoline pumps or other service equipment so that cars block entrance or exit.

RESERVOIR SPACE

Of the basic essentials of a parking garage, perhaps the reservoir space is most important. Skillful driving can overcome poor layout of ramps and stalls. Additional attendants counteract general "slow" design. But inadequate reservoir space limits the operation of the entire garage, and turns away customers during peaks of highest demand.

Required reservoir space depends on the rate of customer demand and the rate at which attendants can put away cars. Customer demand can be assessed by a parking survey and comparison with existing garages, as later described. The rate at which attendants put away cars will depend on the design of the garage and the number and quality of attendants employed. If enough attendants are employed to meet the average demand, then the reservoir space must absorb not only the demand of peak periods, but the individual random peaks in normal periods. Customer flow is not uniform. It is affected by adjacent traffic lights and other street traffic conditions.

A limit on reservoir space is the availability and value of ground level area. Other uses, such as stores and restaurants may appear more profitable and therefore receive first consideration. In some garages, the acceptance and delivery operations take place on other floors. This is not too satisfactory for attendant parking, since it requires additional travel by the customers. The safest move is to make the reservoir space as large as possible, and convert it later, to other uses if necessary.

Garages intended for customer parking do not require as large reservoir space as those for attendant parking. But any possibility of a change from customer to attendant parking makes a full-size space advisable. Finally, reservoir space should not be thought of as "lost," because when parking floors are full, it may be used for storage.

RAMPS

It is generally agreed—and confirmed in the present study—that ramps provide faster over-all operation than do elevators. Although modern elevators may travel one floor in one to two seconds, addi-

tional time is needed to load and unload, open and close the doors, and so on. Since each elevator must make a complete trip with each car (or pair of cars), its rate of acceptance is small compared to a ramp, which is continuously available.

Geometrical shapes that ramps may take vary widely, but all have the common characteristic of a 180° or 360° turn, repeated for each floor of upward or downward movement. Some systems require travel on straight ramps between floors; some on a pair of straight half-floor ramps between vertically staggered floors; some on circular ramps between floors. In systems using straight ramps between floors, turning must be done on the floors. This usually means turning on a flat surface without superelevation.

Average speeds on different types of ramp are about the same, although greater for attendants than for customers, as shown in the following table. This table gives the length of travel path, time, and speed of single floor movements, as measured in typical garages. Squealing tires and apparent rapid movement often observed in garages do not indicate high speed. In this study, no speeds greater than 15 mph were found.

Perhaps a more significant classification of ramps than geometrical shape is their location relative to parking stalls. The two extremes in this case are the sloping floor garage, where all cars are parked adjacent to the ramp, and the "clearway," in which no cars are parked adjacent to the ramp. The advantage of parking adjacent to the ramp is that the ramp does double duty as aisle space, and hence the area per car is smaller. The advantage of the "clearway" principle is that cars moving in and out of stalls do not obstruct the movement of others on the ramp.

Although the travel time of single vehicles is about the same for all types of ramps, one car moving into a stall adjacent to a ramp can block the ramp for as much as a minute. In customer parking garages, some application of the "clearway" principle would seem requisite. In attendant parking garages, the type of ramp can best be chosen in conjunction with other factors, such as the dimensions of the lot and the location of entrances and exits.

It is, of course, desirable to provide separate ramps for up and down movement, but the size and shape of some lots do not allow

this. A double ramp system greatly reduces the delays caused by cars parked adjacent to the ramp, as well as eliminating hazards and delays of meeting traffic.

As mentioned above, considerable turning movements are required in traversing a system of ramps. The number should be kept to a minimum, and adequate superelevation provided to ease the effect of centrifugal force. In the garages studied, the amount of superelevation was small; less than is considered good practice on highway curves (0.1 foot/foot).

The slope of ramps does not seem to affect materially the speed of operation. Slope is a matter of geometric design to fit the available space and the clearance dimensions of cars.

Parking Floors

The most apparent deficiency in older garages is the lack of adequate aisle and stall space. Many garages provide seven-foot or seven-foot-two inch parking stalls. With modern car width averaging six feet and four inches and doors hinged close to the outside of the car, the remaining eight or ten inches are insufficient for a driver to get in and out comfortably or rapidly. Accepted standards are eight-foot stalls, which provide adequate room. The following table shows the time required to back into stalls of various widths from aisles of various widths measured from the end of forward movement in the aisles.

TIME OF PARKING MANEUVER FOR VARIOUS STALL AND AISLE WIDTHS

Aisle Width	14′	15′	16′	17′	18′	19′	20′
7′–0″				a28	a17		c43
7′–6″				a17			
				c46			a21
8′–0″	a38						a14
8′–6″							
9′–							c26

a–Attendant Parking
c–Customer Parking

Caution should be used in accepting any fixed dimensions of cars, since the trend over the life of a garage is quite unpredictable.

This may be illustrated by a quotation from the article in the "Architectural Record:"[5]

> "6 feet 9 inches width per car is sufficient parking width under average conditions. Width in excess of 7 feet is extravagant except in parking garages having a very high turnover."

Since the width of parking stalls is fixed by the size of bays between columns, usually three stalls to a bay, the best way to avoid "dating" the stall sizes would seem to be to eliminate the columns. Accepting for the moment the present nominal car length (19 feet) and aisle widths (20 feet) it can be seen that a not unusual span of 58 feet is required between columns to provide a center aisle with one row of parking on each side. (This matter can be analyzed further on the basis of turning radii and other car dimensions, but is too lengthy to be included here.) By eliminating columns between cars, the garage is adaptable to further changes in car widths, whether they become greater or smaller.

Another feature of parking floor layout is the direction and continuity of aisles. If a short travel path is provided to each stall, with a minimum of turns, operating time can be materially decreased.

Interfloor Driver Travel Means

During peak flows of inbound or outbound movement, the greatest time element is the movement of the attendant returning from the parking floor or going to the floor to get a car. The usual means provided for this movement are stairs, passenger elevator, service elevator (man-lift), or fire poles. Whatever means of interfloor travel is provided, it should be located at the centroid of the parking area, and close to the cashier's cage. A proper location will save steps and lost motion.

In garages with only one or two parking floors in addition to the main floor, stairs may be quite satisfactory. Like ramps, they are always available, and an attendant can travel one floor in about ten seconds. Stairs should be provided as auxiliaries to other means, both for emergency purposes and to facilitate movement between parking floors during two-way operations.

[5] Op. cit.

Passenger elevators are normally used in garages with three or more parking floors, and are generally built in pairs. The floor-to floor travel time is short, but time is lost waiting for the elevator to return from the previous trip. Elevators are essential for customer parking.

Man-lifts provide the most continuous and rapid means of transporting attendants, travelling at seventy-five feet a minute, or requiring about sixteen seconds a floor. Some states and cities have regulations prohibiting their use because of safety considerations. In the garages observed, the man-lifts were popular with attendants and the accident experience was reported to be very low.

Fire poles are efficient for downward travel in attendant parking garages, each drop of one floor requiring about a second. In some garages observed, they were used regularly; in others, scarcely at all.

When an interchange of inbound and outbound cars is taking place, attendants must, of course, drive in both directions. Although driving on a ramp is slower than the other means described above, the time per car handled is less than for one-way movements, especially if an adequate ticketing system is provided which minimizes walking time between the two cars being handled.

ATTENDANT VS. CUSTOMER PARKING

Time values applied to customer-parking do not offer a sound basis of comparison with attendant parking. In the latter, time is of the essence, both in the economic value of the attendant's time and in the quick service attractive to customers. With customer-parking, safety and convenience are more important than time. Many persons prefer self-parking because it allows them access to their car for casual or repeated loading and unloading.

Although the ultimate capacity of a customer-parking garage will be based on the time of critical operations, the total time of acceptance and delivery is not consistent between parkers, and has no general meaning. It may be shown, however, that in a garage with high turnover of short-time parkers, the acceptable charge for each will not be large enough to pay the wages of attendants required to maintain this flow.

PARKING DEMAND

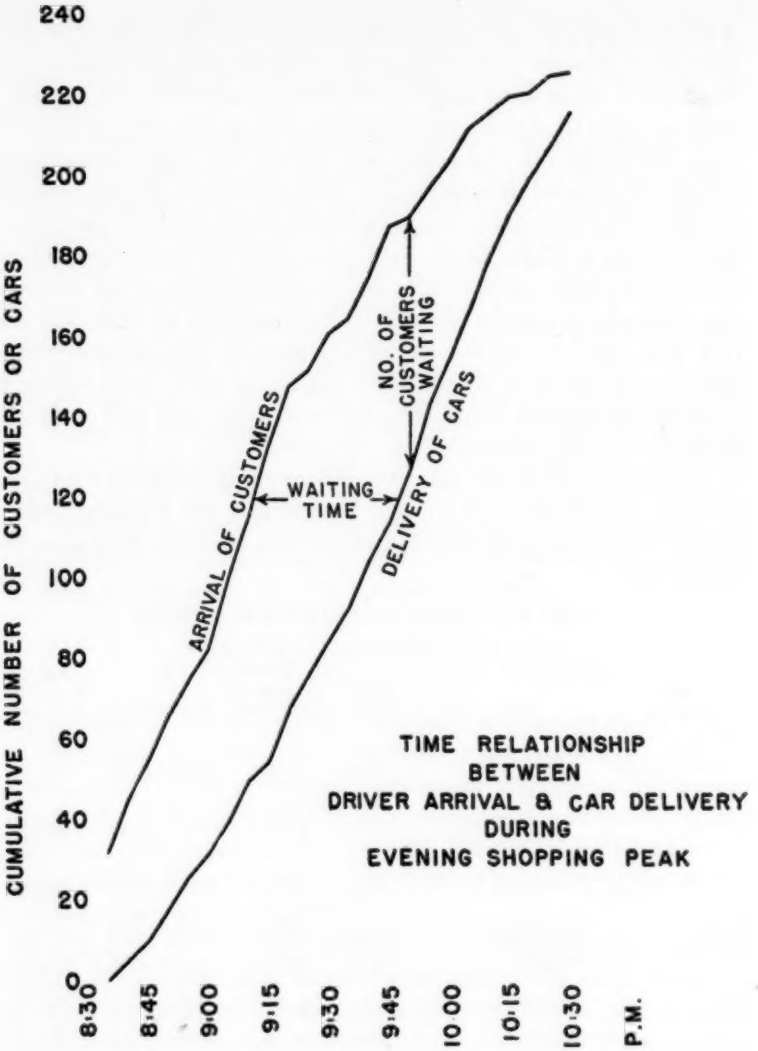
The most difficult parking characteristic to assess is the type and amount of demand. A short discussion may be pertinent. First of all, the current effort in all larger cities today is toward building "solution" garages; i.e., to provide adequate parking at or close to destinations. Although the idea is not new, no city has such a quantity of adequately located off-street spaces. Thus the real parking demand is difficult to determine. Individual garages have solved individual problems, as at single department stores or office buildings, and an estimate of parking demand for similar installations can be derived. One difficulty lies in the fact that most of the older garages have settled into a pattern of serving all-day parkers who are not representative of the over-all problem. Again, in some areas where a tremendous demand exists, the turnover in new and well-operated facilities is even greater than the city average.

A comparison of the rate of turnover in all facilities with that at curbs and in lots and garages is shown in the following table drawn from parking survey data and studies made by the author in two garages.

CARS ENTERING PARKING FACILITIES

PEAK AND AVERAGE FLOWS—WEEKDAYS

Type of Parking	*City*	*No. of Spaces*	*% of Capacity Peak ½ Hour*	*Peak ½ Hour*	*Ave. % Per ½ Hour 8 am–4 pm*
Total: Curb-Lot-Garage in CBD	Providence, R. I., (5)	8089	19%	8:30– 9:00	15.2%
	New Haven, Conn., (6)	3668	27%	10:00–10:30	23.7%
	Atlanta, Ga., (7)	9695	18%	8:30– 9:00	13.2%
Curb	Providence	2070	49%	9:00– 9:30	44.7%
	Atlanta	2366	35%	11:30–12:00	32.0%
Lot	Providence	5144	15%	8:30– 9:00	8.1%
	Atlanta	7329	17%	8:00– 8:30	8.1%
Individual Garages	Shopping garage	282	33%	9:30–10.00	15.7%
	All day parking garage	480	10%	11:00–11:30	5.0%


CUMULATIVE NUMBER OF CUSTOMERS OR CARS
240
220
200
180
160
140
120
100
80
60
40
20
0
8:30
8:45
9:00
9:15
9:30
9:45
10:00
10:15
10:30
P.M.
ARRIVAL OF CUSTOMERS
DELIVERY OF CARS
WAITING TIME
NO. OF CUSTOMERS WAITING
TIME RELATIONSHIP
BETWEEN
DRIVER ARRIVAL & CAR DELIVERY
DURING
EVENING SHOPPING PEAK

Notes: (5) Data computed from "A Parking Survey of the Providence Central Business District 1945," Rhode Island Department of Public Works and Public Roads Administration.

(6) Data computed from "New Haven Parking Study," Connecticut State Highway Department, 1947. Figures include movement only from 10:00 a.m. to 4:00 p.m.

(7) Data computed from "Atlanta Parking Survey," State Highway Department of Georgia and Public Roads Administration, 1946.

The existing demand in these instances is measured by computing the percentage of total available spaces newly occupied each half-hour period on an average week-day. The amount and time of occurrence of peak half-hours and the average during the most active part of the day are shown for each type of facility.

It may be noted that cars entering all facilities average about 18 per cent of capacity per half-hour, while at the "all-day" type of garages and lots, the average is about 8 per cent. At the shopping garage shown, the average flow per half-hour nearly equals that of all facilities combined, and the peak flow is comparable to the curb operation in Atlanta.

It appears that the over-all turnover of "solution" garages may be expected to be 25 to 45 per cent of capacity per hour *throughout the business day*. Although many existing garages now average only 10 per cent per hour, with peak hours around 20 per cent, strategically placed shoppers' garages will actually approach the average turnover at curbs.

DELIVERY DEMAND

Aside from actual damage to cars, the most important factor by which the customer judges a parking garage is the promptness of delivery when he calls for his car. Accordingly, the rate of delivery demand should be assessed, and garage operation keyed to meet it. The outstanding feature of such demand is that at some brief period —closing times of offices, stores, or theaters—a large number of customers arrive in a short time. The accompanying chart shows the demand and car delivery as measured in a popular and modern garage during the peak caused by the closing of department stores. This

peak was not unusual; it recurred each week during normal business seasons.

An accurate count was made of the number of customers waiting for their cars at five-minute intervals, and of the number delivered during each five minutes. The count was started at 7:35 p.m. when some accumulation of customers had taken place, and stopped at 10:30 p.m. when the waiting room was practically empty. The nominal closing hour for the stores was 9 p.m.

The rate of delivery is seen to have two slopes, one preceding 9:15, when some cars were still arriving to be parked, and afterwards, when the operation was entirely outbound. The slope of the latter part of the curve is equal to four minutes per attendant per car (eight attendants working). This is considered normal operating time for this garage: bottlenecks are passenger-elevator operation and long distances attendants must walk on the parking floors. It will be noted that the number of customers waiting exceeded *seventy drivers* in some cases, plus passengers; and that the average waiting time was nearly *thirty minutes. The significant point to any garage operator is that the employment of two more attendants would have reduced these delays by more than half.*

SUMMARY

The efficiency, patronage, and financial success of parking garages depend upon their location, design, and operation. All these factors should be carefully considered in constructing any garage, because location and design are permanent features. In older garages where location and design are obsolescent, operation is the only variable, and several different methods have evolved to fit local physical and business conditions. Unfortunately, however, this has resulted in many garages being operated at minimum cost, minimum maintenance and *minimum service*. It is responsible for present unused garage space in or near congested areas of cities where the parking problem is critical.

Time-motion studies in existing garages form a sound basis for evaluating design and operational features. Off-street parking facilities, because of their concentration of vehicles, are important gen-

erators of traffic—traffic that must be considered in relation to the way it is separated from, or mixed with, existing street traffic. A careful traffic-engineering analysis of parking demand and of the design features of proposed garages will contribute much to successful operation in later years.

Progress in the National Status of Urban Arterial Routes

JOSEPH BARNETT

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TRAFFIC congestion is already upon us in most cities. It requires little imagination to visualize the extent to which congestion will increase as vehicles rolling off assembly lines add to the number in operation. 1947 registrations will include more than 37,000,000 motor vehicles—several millions more than pre-war registration. And the automobile industry is producing at the rate of about 4-½ million cars a year. This article will describe some of the measures being taken to meet existing and potential congestion.

It is becoming generally recognized that congestion in cities will be relieved only by a broad program which I like to divide into five general categories:

1. The construction of new arterial routes and the improvement of existing ones to permit the free flow of arterial traffic.

2. Improvement of our city streets for proper distribution of traffic and the servicing of adjacent property.

3. Solution of the terminal problem by providing proper facilities for parking and for the loading and unloading of goods.

4. Improvement of our transit system, particularly in large cities. We cannot expect the private automobile to handle peak

loads bound to and from work. In a few extreme cases it may become necessary to bar private automobiles in limited areas for short periods of time. Improved rail facilities, particularly for delivering goods to industry, might come in this category.

5. Improved operation of facilities we now have.

It is not the purpose of this article to delve into history of events that have led to present conditions; nor to discuss city planning and its relation to traffic. Discussion of this subject can be found in the report, "Interregional Highways," House Document 379 of the 78th Congress, 2nd Session, and in the article "Express Highway Planning in Metropolitan Areas" in the March 1946 Proceedings of the American Society of Civil Engineers, as well as in numerous other articles.

Out of all this discussion emerges the thought that the necessary broad attack requires careful planning of all phases of communal service and that the backbone of an adequate plan is the development of a *system of arterial routes* that fits existing conditions and commitments as far as feasible. It should be a system on which all future planning can be based.

Cities Planned Before Motor Age

City planning traditionally has consisted of studies and plans for dividing the community into sections adaptable to the various forms of community life, making adjustments to fit conditions that had developed through the years without formal planning, and providing a framework of needed services for the various needs of the community and its parts. Arteries for the movement of people and goods were developed long before the motor age. Rivers, which were the most important transportation medium during the early days of our country, influenced the location of most of our cities, and profoundly affected the locations of buildings and streets. The location of railroads between control points was influenced chiefly by topography. Street locations were sometimes dictated by topography, but otherwise they were laid out in a grid pattern to fit rivers, harbors, and railroads. They served their intended purpose, as ways to the property along them, fairly well.

The need for city planning developed in most cases after the street pattern was set. It developed as improvements on land mounted in size and changed in character, and as improvements such as those of an industrial nature interfered with the full use and enjoyment of improvements of a quite different nature such as homes. Most city planners recognized the need for an orderly development of the means of transportation along with the need for solving numerous other problems that developed with the growing city; problems relating to health, education, recreation, fire prevention, law enforcement, utility services, etc.

This is manifest in many city plans by suggestions for improvement of streets, generally by widening. City plans have had a favorable effect on city development, but they were too few and too conservative to accord with the tremendously accelerated pace of city life that accompanied the growth of the motor vehicle and the demonstration of its potentialities for freedom of movement.

Arterial Routes Are Backbone of City Plan

The Federal-aid Highway Act of 1944, by authorizing a separate fund for aid in the relief of traffic congestion in cities, activated the Federal-State cooperation in developing arterial routes in cities which previously had operated so successfully in the improvement of our rural highway system. Determination of the routes in cities which, when improved to high standards, would contribute most to the relief of traffic congestion was no simple matter. In rural areas the location of a highway between terminals is frequently determined predominantly by topography. In urban areas arterial route improvements can have a profound effect upon the entire city plan. These route improvements form a backbone on which all other elements of the city plan can be based.

Realization of this fact gave far-reaching impetus to city planning. Cities that previously had little or no city planning found it necessary to study their overall city problem before locating a route which, when improved, would effect the entire community. City plans that envisioned street-widening as major street improvement had to be restudied and new plans prepared, because every other element in

city planning had to be located with respect to arterial route improvements.

Planned locations for buildings and groups of buildings not yet constructed can be changed without too much difficulty. House mover and contractor are not required. An arterial route, however, once general location is established, can be adjusted only within relatively narrow limits.

Factual Data Are Necessary

In attempting to locate arterial routes, it generally was found that facts to determine their location were not available. In many cities, the only determination made was based upon opinions of engineers and planners acquainted with local conditions. These opinions, however, were subject to personal leanings. Moreover, they were vulnerable to attack from others who could offer solutions which, in the absence of factual data, had to be considered just as reasonable. Even sound judgment could not be considered unimpeachable unless backed by factual data.

Factual origin-destination and parking data are difficult neither to obtain nor analyze. And the procedure is not costly in the light of improvement expenditures involved. The comprehensive home-interview type of origin-destination survey has now been undertaken in a sufficient number of cities so that "bugs" in this method have nearly all been eliminated.

The cost is about 10 cents a person in large cities of around 1,000,000 population or more. The cost per person increases as population decreases, reaching about 17 cents a person for cities in the 50,000 to 100,000 population group. A parking survey in the downtown area, generally needed to supplement the O-D survey, costs about $20,000 additional when made in cities in larger group.

Cost and Method of Less Expensive Surveys

But cost, time and effort of a comprehensive home-interview survey are not justified in every city. While this method has been used successfully in cities as small as 15,000, reliable origin-and-destination

data adequate to establish the locations of arterial routes and indicate the general type of design can be obtained in small cities at less cost by other methods. In one method, drivers of vehicles are interviewed as they park. Data are obtained not only as to parking habits and desires but also as to the origin, destination and purpose of the trip. Such surveys cost from $4,000 to $8,000.

In another method, O-D data are obtained from vehicles passing two or more cordons of survey stations. One cordon generally is located around the edges of the urban area and another around the central business district. The data are obtained best by interviews although postcard questionnaires are sometimes used. This method is successful where knowledge regarding trips between different sections of the city outside the central business district does not have an important bearing on the problem. The cost by this method is only about 5 cents a person.

The value of adequate and reasonably accurate traffic data lies beyond the determination of desirable locations of arterial routes. In many cases, locations of arterials can be determined with meager traffic data. But analysis of effects upon the existing street system, a determination of the placement of accesses, and of traffic loads for which they should be designed cannot properly be made without detailed data.

Planning-survey organizations of various states have cooperated with cities and the Public Roads Administration in making origin-and-destination surveys in over sixty cities,[1] and parking surveys have been made in twenty-three additional cities.

Practical Methods of Procedure

To coordinate the study of needs of various communal services and to obtain approval of agencies interested in the development of our cities, it generally is found desirable to prepare preliminary engineering reports that present the problem and give the proposals for its solution in some detail. Such reports generally include an introduction describing the city, its existing streets and roads, a gen-

[1] A list of cities for which origin-destination surveys have been made or are being made is given in Appendix A. A list of cities for which parking surveys have been made or are being made is given in Appendix B.

eral description of the project and its place in a master plan, if any. This is followed by a chapter presenting facts of motor vehicle and other forms of travel and, in some cases, facts on the physical characteristics that affect and are affected by the project.

This may be followed by a discussion of possible locations, giving various alternate routes studied, comparative costs, and possibly an economic analysis. There should be a chapter on design features and standards and possibly preliminary plans of contemplated projects with rights-of-way to be acquired and estimates of the cost.

The report should close with a proposed method of financing and a summary of recommendations. Essential features of proposals should be shown in a form, readily understandable by laymen who have no training in engineering. Perspective delineations are excellent for this purpose. Such a report goes a long way in consolidating opinion in favor of the projects. Such a report helps also in publicity ventures so necessary in obtaining support. Preliminary engineering reports have been made or are in process in about 100 cities.[a]

Ways in Which Federal Funds Are Used

We may well ask what has been done and what is being done to relieve traffic congestion in cities aside from the planning of projects. An answer regarding one phase of the necessary broad attack, that of the improvement of arterial routes, can be obtained by examination of the work being done with funds provided to aid states in work authorized by the Federal-aid Highway Act of 1944.

The Act authorized funds for assisting states in the amount of $500,000,000 for each of three postwar years—fiscal 1946, 1947, and 1948—available under recent legislation until June 30, 1948, 1949, and 1950 respectively. One hundred and twenty-five million dollars of each year's apportionment is earmarked for improvements on the Federal-aid system inside urban areas of cities of 5000 population or over in accordance with 1940 Federal census; $225,000,000 for improvements on the Federal-aid system, both rural and urban, and $150,000,000 for improvements of secondary or farm to market roads outside the urban areas.

[a] Listed in Appendix C.

These funds have to be matched by the states in equal amounts where the funds are to be used for construction. Where they are to be used for purchase of a right-of-way, the proportions are 1/3 and 2/3 state. The Federal participation is somewhat higher in states with large areas of public lands. Up to 10 percent of Federal-aid funds can be used for eliminating hazards at railroad crossings. Such funds need not be matched by the states.

A Way to Determine Metropolitan Areas

The planning of arterial routes began before the passage of the Federal-aid Highway Act of 1944. Anticipating it, planning during the war years had progressed in many cities. Otherwise the splendid showing of origin-destination surveys, parking surveys, and preliminary engineering reports could not have been made. The work was financed by cities, counties, and states and by funds provided by previous Federal-aid acts. Planning continued into and overlapped the programming and construction period. In many cases it used part of current Federal-aid funds.

To conform with the intent of the Act, each state was requested to determine the urban area of each community and to file maps showing that area. Each urban section had to include the incorporated area but it could include also land outside the corporate limits which were or probably would be, urban in character. Satellite communities such as city suburbs could be included regardless of size. In some cases a satellite community in an adjoining state was included although expenditures therein had to be made by the adjoining state. Two or more communities whose urban areas overlapped could be presented as one urban area. Thus for the first time, planning in a major sense could be done regardless of corporate or political boundaries. The community as an entity could be considered realistically.

Maps of urban areas submitted by states and approved by the Public Roads Administration have practically been completed. Of the 2070 communities of 5000 population or over, all but 61 have been included in the list of approved urban areas.

$181,450,000 in Federal Aid for Urban Areas

Following the submission of urban area maps, states prepared programs of improvements for each year. Programs are declarations of intent. These programs, when approved, reserve funds for the intended improvements and enable states to advance the projects to the stage of plans, specifications, and estimates, ready for letting construction contracts. By and large, little money authorized for the Federal-aid system was programmed for use in cities. The backlog of essential projects accumulated during the war was too great to divert such funds to the Federal-aid system in urban areas. An examination of the programs for the use of Federal-aid *urban* funds gives the entire picture as far as State-Federal cooperative projects in cities are concerned.

Programs of projects approved to September 15, 1947, involve $105,500,000 of 1946 Federal-aid urban highway funds, $63,710,000 of 1947 funds and $12,240,000 of 1948 funds—a total of $181,450,000 or 48.7 percent of the apportionment of funds specifically authorized for expenditure within urban areas by the Federal-aid Highway Act of 1944. With matching-funds provided by the states, approved programs for less than half the urban Federal-aid funds authorized and apportioned represent about $360,000,000. This is chiefly for construction since few states elected to use Federal-aid funds for the purchase of right-of-way.

Programmed Federal-aid urban highway funds and the states' matching funds do not give a complete picture of the effort to improve arterial routes in urban areas. Some states, Texas for instance, receive assistance from cities that purchase all rights-of-way. In some states, cities and states share in the purchase of rights-of-way without Federal-aid. Some cities and counties, Illinois and Michigan for instance, provide funds for two-thirds of the cost of the project. State-Federal-aid provides one-third. Some cities, for example New York, improve additional arterial routes entirely with city funds; others share with the state only in the cost of many arterial route improvements. Estimates of amounts thus provided are not readily available, but they make a sizeable addition to sums programmed under the Federal-aid urban apportionments.

5 Kinds of Urban Projects Are Federal-Aided

Let us examine the character of the projects financed with Federal-aid urban funds matched by the states. For convenience, the projects are divided into five classifications:

Class I—Minimum Standards, involving widening or resurfacing to increase traffic capacity to some extent but not sufficient to provide an additional traffic lane or its equivalent.

Class II—Intermediate Standards, involving widening projects not listed under Class I. Widening varies from the equivalent of one additional traffic lane to several. Projects providing a median are not included. A typical project of this class would be widening of an existing street from 36 feet to 50 feet between curbs.

Class III—High-type Standards, involving divided pavements at grade without controlled access. Projects in this class may include channelization at intersections and an occasional highway grade separation. Such projects are of material value in reducing accidents and in providing facilities for the free movement of traffic, but their capacity is restricted by crossings at grade where traffic lights are necessary for the safety of pedestrians and vehicles.

Class IV—Expressways or freeways which provide two or more lanes in each direction for moving traffic, with opposing traffic streams separated and with all cross traffic and pedestrian traffic at grade eliminated. Expressways may be depressed or elevated or at grade, or a combination of these. Intersecting streets are carried over or under the expressway and ingress and egress are provided only at selected locations. Abutting properties are serviced by frontage roads or streets which are separated from the expressway proper. Expressways are free-flowing facilities which accommodate large volumes of traffic with comfort and safety. Because of the complexity of construction and the high cost of an expressway, numerous construction projects are required to complete a facility.

Class V—Railway-highway projects, usually grade separation structures. A few projects involving protective devices at grade crossings are included.

Amounts programmed, the number of projects, mileage in-

volved, and the percentage of the total are shown for each class of work in the following table:

CLASSIFICATION OF FEDERAL-AID URBAN HIGHWAY FUNDS PROGRAMMED as of September 15, 1947

	Class I	Class II	Class III	Class IV	Class V	Total
			1946 Funds			
Number of projects	74	197	60	87	42	460
Mileage involved	58	205	93	82	10	448
Amount	$4,920,000	$21,670,000	$20,610,000	$43,650,000	$14,650,000	$105,500,000
% of total	4.7	20.5	19.5	41.4	13.9	100.0
			1947 Funds			
Number of projects	21	77	34	61	22	215
Mileage involved	25	100	49	62	4.2	240.2
Amount	$1,260,000	$10,360,000	$10,090,000	$35,850,000	$ 6,150,000	$ 63,710,000
% of total	2.0	16.2	15.8	56.3	9.7	100.0

The percentage of Federal-aid urban highway funds programmed for expressway projects is materially greater for 1947 funds than for 1946 funds and the percentage of funds for Class I is small—less for 1947 funds than for 1946 funds. Few states have submitted programs for expenditure of 1948 Federal-aid urban highway funds, and the total of approved programs is not yet sufficiently large to permit a significant classification.

Approximately 30 percent of the urban projects in all approved programs are under construction[8] or under contract for construction. Plans, specifications and estimates have been approved for approximately 12 percent, but they are not yet under contract for construction. The remaining 58 percent are not advanced beyond the programmed stage.

Considerable delay in starting and carrying on construction has been caused by shortages of material, labor, and equipment, rising prices that upset financial programs, by reluctance to cause further

[8] A list of projects under construction or about to be constructed in several cities with a brief description of each is given in Appendix D.

increases in cost by the increasing demand for critical products such as steel, and by reluctance also to compete with other essential needs such as housing.

There has been delay in starting construction on several projects of major importance where right-of-way was occupied by dwelling units. Public officials' hesitation to force home owners and tenants to move is understandable. With the housing shortage as serious as it is, and with the relief therefrom a long-range matter, it is a major problem to clear rights-of-way improved with homes. Some cities faced this problem realistically and in various ways cleared the right-of-way without imposing undue hardships on tenants.

In Los Angeles, right-of-way agents of the district office of the State Highway Department assisted tenants in finding other places to live and enlisted the aid of the local housing authority. They also arranged for moving many houses. In Hammond, Indiana, where houses were moved, the state bought only the land and paid for moving the houses and other incidentals including an "inconvenience fee."

Aid from a local bank was obtained to refinance each home owner and issue a new mortgage. In New York City, a Tenant Relocation Bureau was set up on each project to aid tenants in finding new living quarters and in arranging for moving many homes for which emergency legislation was obtained. In all these undertakings, cooperation, or at least the understanding, of tenants was obtained when the importance of the proposed improvement was brought home to them and they were convinced that officials would really construct the project, and would in addition do everything in their power to help tenants find new quarters with a minimum of hardship.

Despite delays, the showing is far from disheartening. The amount of Federal-aid in urban funds authorized is short of needs for arterial route improvements. Yet considered in the light of expenditures normally made by cities for all their roads and streets, the Federal authorization will tremendously augment such expenditures. Mileage of projected expressways compared with that of existing free-flowing arteries in cities is favorable: the present program will double such mileage.

No Congress in the last quarter-century has failed to examine seriously the nation's highway needs and to provide for them in greater or less degree in cooperation with the states. It is reasonable to assume that future Congresses will do likewise.

The arterial route improvement program, begun as a Federal-state cooperative undertaking, can be expected to continue. When combined with the efforts of cities, counties, and states to improve additional arterial routes and to solve other phases of the necessary broad program, we can look forward to a real relief of traffic congestion in our cities.

APPENDIX A

Metropolitan Area Traffic Studies
Made or to be Made

Allentown-Bethlehem, Pa.
Atlanta, Georgia
Augusta, Georgia
Baltimore, Maryland
Baton Rouge, Louisiana
Bay City-Saginaw, Michigan[7]
Boston, Massachusetts
Charlotte, North Carolina
Charleston, South Carolina
Chattanooga, Tennessee
Cincinnati, Ohio[1]
Columbus, Georgia[2]
Denver, Colorado
Fort Wayne, Indiana
Grand Rapids, Michigan
Greenville, South Carolina
Harrisburg, Pennsylvania
Honolulu, Hawaii
Indianapolis, Indiana
Jacksonville, Florida
Kalamazoo, Michigan
Kansas City, Missouri[3]
Knoxville, Tennessee
Lincoln, Nebraska
Lansing, Michigan
Little Rock, Arkansas
Macon, Georgia
Mason City, Iowa
Memphis, Tennessee
Milwaukee, Wisconsin
Muskegon, Michigan
Nashville, Tennessee
Newark, New Jersey
New Orleans, Louisiana
Oklahoma City, Oklahoma
Omaha, Nebraska[4]
Ottumwa, Iowa
Philadelphia, Pa.[6]
Phoenix, Arizona
Pontiac, Michigan
Port Huron, Michigan
Portland, Oregon[5]
Providence, Rhode Island
Reading, Pennsylvania
Richmond, Virginia
St. Joseph, Missouri
St. Louis, Missouri
Salt Lake City, Utah
Savannah, Georgia
San Francisco-Oakland, California
Seattle, Washington
Shreveport, Louisiana
South Bend, Indiana
Spartanburg, S. C.
Springfield, Missouri
Spokane, Washington
Tampa, Florida
Tulsa, Oklahoma
Waycross, Georgia

[1] Includes Covington, Kentucky
[2] Includes Phoenix City, Alabama
[3] Kansas City, Kansas
[4] Includes Council Bluffs, Iowa
[5] Includes Vancouver, Washington
[6] Includes Camden, New Jersey
[7] Not started

APPENDIX B

Where Parking Studies Were Made or Are Under Way

New Haven, Connecticut
Jacksonville, Florida
Atlanta and Athens, Georgia
Alexandria and Monroe, Louisiana
Baltimore, Maryland
Albert Lea, Minnesota
Portsmouth, New Hampshire
Portland, Oregon
Harrisburg and Reading, Pennsylvania
Providence and Pawtucket, Rhode Island
Anderson, South Carolina
Nashville, Knoxville, and Chattanooga, Tennessee
Corpus Christi, Texas
Salt Lake City, Utah
Seattle, Walla Walla, and Spokane, Washington

APPENDIX C

Preliminary Engineering Reports Made or Are to Be Made

Ada, Oklahoma
Akron, Ohio
Albany, New York
Albuquerque, New Mexico
Alexandria, Louisiana
Amarillo, Texas
Arlington County, Virginia
Atlanta, Georgia
Auburn, Maine
Austin, Texas
Baltimore, Maryland
Baton Rouge, Louisiana
Boston, Massachusetts
Beaumont, Texas
Bridgeport, Connecticut
Brunswick, Georgia
Buffalo, New York
Casper, Wyoming
Chattanooga, Tennessee
Chicago, Illinois
Cincinnati, Ohio
Cleveland, Ohio
Concord, New Hampshire
Covington, Georgia
Dallas, Texas
Dayton, Ohio
Daytona Beach, Florida
Denton, Texas
Denver, Colorado
Detroit, Michigan
East Providence, Rhode Island
El Paso, Texas
Evanston, Wyoming
Fort Wayne, Indiana
Fort Worth, Texas
Fostoria, Ohio
Grand Island, Nebraska
Gainesville, Texas
Glastonbury, Connecticut
Greenville, Texas
Hartford, Connecticut
Houston, Texas
Jacksonville, Florida
Kansas City, Missouri

PRELIMINARY ENGINEERING REPORTS, Cont'd.

Kalamazoo, Michigan
Knoxville, Tennessee
Las Cruces, New Mexico
Las Vegas, Nevada
Lake Charles, Louisiana
Lewiston, Maine
Little Rock, Arkansas
Longview, Texas
Los Angeles, California
Louisville, Kentucky
Lubbock, Texas
Lynchburg, Virginia
Mansfield, Ohio
Martinsville, Virginia
McAlester, Oklahoma
Minneapolis, Minnesota
Monroe, Louisiana
Morgantown, West Virginia
Nashville, Tennessee
New Haven, Connecticut
New Orleans, Louisiana
Newport, Georgia
New York, New York
Niagara Falls, New York
Omaha, Nebraska
Palestine, Texas
Paris, Texas
Petersburg, Virginia
Pine Bluff, Arkansas
Pittsburgh, Pennsylvania
Peoria, Illinois
Portland, Oregon
Providence, Rhode Island
Pueblo, Colorado
Quincy, Illinois
Richmond, Virginia
Rockford, Illinois
San Angelo, Texas
San Antonio, Texas
San Francisco, California
Santa Fe, New Mexico
Savannah, Georgia
Seattle, Washington
Shreveport, Louisiana
St. Louis, Missouri
St. Paul, Minnesota
Suffolk, Virginia
Staunton, Virginia
Toledo, Ohio
Topeka, Kansas
Trinidad, Colorado
Tyler, Texas
Washington, D. C.
Waynesboro, Virginia
Waterbury, Connecticut
Youngstown, Ohio

APPENDIX D

Current Status of Construction on Federal-aid Expressways

California

The Hollywood-Santa Ana Freeway in Los Angeles is to be of 6 and 8 lanes divided, with controlled access. Of a total proposed length of 14.5 miles, about 6 miles are now under construction. Several highway grade separation structures are also under construction on the remaining 8.5 miles. The work under construction involves $5,600,000 of Federal funds.

The East Shore Freeway from Oakland toward San Jose is to be 6 lanes divided, with controlled access. Several highway grade separation structures

and some grading are under construction within a length of 6.2 miles. $2,200,000 of Federal funds are involved in the work under construction.

The Balboa Parkway, or Cabrillo Freeway, in San Diego from "A" Street to the north city limits, about 6.5 miles, is to be a 4-lane divided controlled access facility. It is now under construction with $1,023,600 of Federal urban highway funds participating.

The Bayshore Freeway is to be a controlled access facility of 6 lanes divided extending from 5th Street in San Francisco through the city and through South San Francisco to San Mateo and San Jose. Some work, involving $2,350,000 of Federal funds, is under contract in San Francisco and between that city and Burlingame. Approximately 7.5 miles, including several structures, are under contract. An extension of the Bayshore Freeway 0.63 mile long, is under contract at San Jose with $213,600 of Federal funds participating. Construction is to be 4-lane divided.

Colorado

The Valley Highway is a proposed controlled access facility of 4 lanes divided to extend north-south across Denver for 9.3 miles. Part of it has been programmed but none is yet under contract.

Connecticut

The North Meadows Express Highway from the west end of the Bulkeley Bridge in Hartford northerly to Windsor is to be a controlled access facility of 4 lanes divided, about 3.5 miles in length. Several projects are programmed but none are yet under contract.

About 5.5 miles of the Wilbur Cross Highway from East Hartford to Manchester are under construction. The work involves construction of 4-lane divided pavement and several grade separation structures. About $920,000 of Federal funds are involved.

District of Columbia

The elevated highway on K Street in Washington from 27th Street to Key Bridge, a length of 0.79 mile, is to be a reinforced concrete and steel viaduct carrying two 22-foot roadways separated by a 4-foot median. It is now under construction with $1,733,000 of Federal funds participating.

Illinois

Right-of-way is being acquired for the Congress Street Expressway in Chicago, which is to be 13.5 miles in length, of 8 lanes divided and with controlled access. $2,250,000 of Federal funds are participating in right-of-way acquisition over 2.75 miles. City and county are also acquiring right-of-way without Federal participation. Demolition contractors are clearing the right-of-way.

Kentucky

Construction in Louisville of a proposed 4-lane divided controlled access expressway from the Municipal Bridge over the Ohio River, southerly to Crittenden Drive, about 3 miles, has been postponed indefinitely because the housing shortage precludes demolition of dwellings.

The proposed Eastern Expressway at Louisville from a point near Lyndon westerly into the city is to be a 4-lane divided controlled access highway about 10 miles in length. Several projects are programmed but none are yet under construction.

A Southeastern Expressway extending southeasterly for about 6.5 miles from an intersection with the Eastern Expressway in the eastern part of the city is also proposed but no work has yet been programmed.

Louisiana

The State of Louisiana has undertaken construction of a 4-lane divided controlled access highway on U. S. 90 from a point west of Sulphur through the city of Lake Charles to an intersection with U. S. 165 about 12 miles east of that city. Total length is about 27 miles, of which 3.5 miles are in Lake Charles. Two projects have already been programmed and one of these, involving construction of the substructure for and approaches to a bridge over the Calcasieu River at Lake Charles is now under contract with $1,317,000 of Federal funds participating.

Massachusetts

A six-lane divided controlled access expressway is proposed in East Boston from Central Square to the McClellan Highway with a connection to the Airport and also giving access to the Sumner Tunnel. Length is 1.16 miles. The entire project is programmed but it is not yet under contract.

Michigan

$2,000,000 of Federal funds are participating in the acquisition of right-of-way for 5 miles of the John C. Lodge Expressway in Detroit. The expressway is to be a six-lane divided, controlled access facility. An additional $500,000 of Federal funds is being used for elimination of a railway grade crossing now under construction on the expressway.

Right-of-way for 5 miles of the Edsel Ford Expressway in Detroit with $2,000,000 of Federal funds participating. The expressway is to be a six-lane divided, controlled access facility approximately 13.5 miles long. Elimination of a railway grade crossing is under construction, $500,000 of Federal funds participating.

Missouri

The proposed Southwest Trafficway in the northwestern part of Kansas City is to be a six-lane divided, controlled access expressway to extend from the

proposed 6th Street Trafficway to the Kansas line to connect with proposed trafficways in Kansas City, Kansas. Length is about 3 miles. Part of the proposed construction is programmed but none is yet under contract.

The proposed 6th Street Trafficway in Kansas City is to be a 4 and 6-lane divided, controlled access expressway to extend from the Intercity Viaduct to the Armour, Swift, Burlington Bridge, approximately 1.5 miles. Nothing has yet been programmed.

New Jersey

Grading is now under way near Elizabeth on 3 miles of State Route 100 which is to be a multiple lane, controlled access, expressway on new location from the Raritan River to the George Washington Bridge, a total length of about 36 miles. The grading now under construction involves $1,030,000 of Federal funds.

The State proposes to construct a Parkway on new location for State Route 4 from a point on State Route 6 south of Paterson southerly through or near Bloomfield, East Orange, Irvington, Cranford and Iselin to State Route 35 north of the Raritan River, about 27 miles. Initial construction is to be four lanes divided, with provision for additional lanes when needed. Several projects have been programmed and one, involving grading on a length of 2.08 miles near Cranford, is now under contract with $251,235 of Federal funds participating.

New York

The Cross Bronx Expressway is a proposed 6-lane divided controlled access facility, part elevated and part depressed, extending from the Washington Bridge over the Harlem River easterly following the general line of East 174th, East 176th and East 177th Streets to the Hutchinson River Parkway north of LaFayette Avenue, a length of 5.4 miles. Several projects have been programmed but none are yet under contract. The city is acquiring right-of-way and demolition of structures is progressing.

The Van Wyck Expressway is a proposed 6-lane divided controlled access facility extending from Queens Boulevard southeasterly on the general line of Van Wyck Boulevard to Southern Parkway and Idlewild Airport, about 3.8 miles. The city is acquiring right-of-way, most of which is now cleared. Several projects have been programmed and one, involving construction of 0.6 mile near the southern end of the expressway, is now under contract with $869,000 of Federal funds participating.

The Brooklyn-Queens Connecting Highway is a proposed 6-lane divided, controlled access facility, part of it elevated, extending about 2.15 miles from a point near Kent Avenue in Brooklyn northeasterly to the existing Kosciusko Bridge. Several projects are programmed and two, involving partial construction on a length of 1.9 miles, are now under construction with $647,500 of Federal funds participating.

The Major Deegan Boulevard is a proposed 6-lane divided controlled access elevated highway extending from a point in the Bronx near 138th and Exterior Streets northerly along the east side of the Harlem River to Van Cortlandt Park, about 6 miles. One project has been programmed but is not yet under construction.

The Prospect Avenue Expressway in Brooklyn is a proposed six-lane divided controlled access facility extending from Gowanus Elevated Highway southeasterly along Prospect Avenue to Ocean Parkway, about 1.6 miles. No work has yet been programmed.

The Bronx River Expressway, southerly extension of the Boston Post Road, is a proposed 6-lane divided, controlled access facility extending from East Tremont Avenue southerly across the Cross-Bronx Expressway and along the west side of the Bronx River to Faile Avenue, about 1.45 miles. No work has yet been programmed.

The New England Thruway is a proposed 6-lane divided controlled access facility extending through Bronx County from the intersection of Eastern Boulevard and Westchester Avenue northerly and northeasterly across the Hutchinson River Parkway to the Bronx-Westchester County line, about 3 miles. No work has yet been programmed.

Ohio

About 2.5 miles of the East Shore Drive from Cleveland toward Painesville is now under construction with $600,000 of Federal funds participating. Present construction involves 2 lanes of new pavement which, with the existing pavement will provide a 4-lane divided facility. Ultimate construction is to be 6 lanes divided.

The proposed Willow Freeway in Cleveland is to be a 4-lane divided, controlled access facility, about 4 miles in length from a point south of Cuyahoga Heights northerly toward the central city to connect with the proposed Newburgh Freeway. One highway grade separation structure involving $450,000 of Federal funds is under contract. Other projects are still in program status.

U. S. 25 in Cincinnati is proposed for development as a four- and six-lane divided controlled access facility through the city from the Ohio River northerly for 11.7 miles. Two projects in the northern part of the city are programmed, but neither is under contract.

Oregon

The Front Avenue-Harbor Drive development in Portland is a 4-lane divided semi-freeway extending from Abernethy Street and Barbur Boulevard northerly along the west side of the Williamette River to Steel Bridge and from Steel Bridge northerly along the east side of the river to the intersection of River Street and Interstate Avenue, about 2 miles. The portion west of the Williamette River is completed with the exception of 0.5 mile which is programmed but not yet under construction.

Pennsylvania

Almost 2 miles of the Penn-Lincoln Freeway are under construction at Pittsburgh with $1,450,000 of Federal funds involved. The Freeway is to be of 4 and 6 lanes divided, on new location with controlled access, and is to carry U.S. Highways 22 and 30 from a point east of Pittsburgh into the center of the city. Length is about 9 miles.

Texas

U.S. 75, extending through Houston from northwest to southeast on new location for about 11 miles is to be a 4- and 6-lane divided controlled access expressway except for about 1 mile near the center of the city where 4 surface streets are to be used as one-way streets. About 4.2 miles, including the improvement of the 4 surface streets, are now under construction with $3,800,000 of Federal funds involved.

The Central Boulevard in Dallas is a proposed 4- and 6-lane divided, controlled access facility extending from the Trinity River Bridge about 0.4 mile south of the city northerly through the city and beyond to State Route 114. The approximate length of 9.75 miles includes 1.85 miles in the city where two parallel surface streets are to be used for two way traffic on each street. Three projects involving a length of 1.8 miles are under contract with $912,300 of Federal funds participating.

About 0.7 mile of a proposed 4-lane divided, controlled access expressway to extend from the northwestern portion of San Antonio into the center of the city is now under construction. Present construction involves about $900,000 of Federal funds.

2.7 miles of a 4-lane divided, controlled access expressway from the southern portion of Fort Worth into the center of the city are now under construction with $1,100,000 of Federal funds participating.

An east-west expressway of 4 and 6 lanes divided, with controlled access is also proposed in Forth Worth along the general line of Rosedale Street, Vickery Boulevard, Lancaster Street and northeasterly to Ederville Road. Four projects are programmed but none are yet under contract.

Washington

A double-decked viaduct, each deck to be 40 feet wide between curbs, is proposed on Alaskan Way in Seattle from Battery Street near First Avenue to a point south of King Street, about 1.5 miles. Later it is proposed to extend the viaduct south along South Alaskan Way and East Marginal Way and to construct a depressed roadway to the north along Battery Street or Wall Street to connect with Aurora Avenue at Denny Way. No construction work has been programmed as yet.

Among other cities where expressways are being considered but have not yet reached the program stage are:

Atlanta, Georgia
Fort Wayne, Indiana
Providence, Rhode Island
Richmond, Virginia
Baltimore, Maryland.

NOTE: Cost estimates are only approximate and probably are too low in view of present prices.

Travel Speeds and Posted Speeds in Three States

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EVERY motorist has asked himself many times "Are speed limits based on sound engineering principles, or are they intended to frighten me into driving slowly?" After a while, the motorist can answer his own question for the community in which he lives and for routes over which he frequently travels. He becomes familiar with road hazards, traffic characteristics, and enforcement policies. By relating those to his own desires, he arrives at a travel speed that may agree with the legal limits or may deviate from them widely.

Certainly the public should place strict emphasis on speed control, as should public officials, and official agencies. The fixing of speed limits assumes significance in the work of traffic engineers, enforcement agencies and others responsible for traffic control. Development of safety-consciousness in the motoring public invariably involves matters of speed regulation.

Differences between highway capacities and motor vehicle abilities are of major import in the field of speed control and regulation. On rural highways as well as on city streets, speed factors become increasingly important as vehicle density increases and as varied vehicle types are involved.

Attitudes in Fixing Speed Limits

The common tendency of officials in enacting speed laws and posting limits has been to establish values that are generally recognized as over-restrictive in terms of the normal driving habits of the average motorist. There has been too much of the old attitude of "fix the limit at 20 m.p.h. if you expect people to drive 30 m.p.h." In some cases, however, legislative bodies and public officials have taken a more progressive attitude and have attempted to provide speed

limits compatible with roadway safety factors, traffic volumes, and road-user abilities.

The difference between these two almost opposite approaches has resulted in widely varying limits in different political jurisdictions. As a result, it is difficult to relate "driving speeds" to "legal speeds." Almost without exception, the posted values are exceeded appreciably by the average driver—even at the risk of arrest. This indicates either that calculated limits are too low, or that most drivers are incapable of determining safe and reasonable limits. Yet traffic authorities generally agree that few motorists drive at unsafe speeds in the light of discernible conditions of roadway and traffic. The practice, therefore, of using 85 percentile or other values of measured speeds in establishing speed zones is to some extent to acknowledge that under given conditions most operators drive sanely. This tends to warrant the conclusion that many speed limits are too low for normal driving conditions. Much can be said for and against this general statement.

Unreasonable speed limits lessen motorists' respect for all posted speeds and tend thereby to make speed signs ineffective. Too often drivers have been told, "drive carefully and avoid accidents." The aid that reasonable limits and advisory speed signs can give them should be used in shaping legislative and administrative speed policies. Drivers should not merely be told to drive safely; they should be told *how* to drive safely; and officials should demonstrate their own willingness to be reasonable. Obviously unreasonable traffic regulations will cause only contempt and disregard by motorists for the regulations and will likely destroy their confidence in the sincerity and judgment of traffic officials. These conditions are proven by examples where top speeds on given streets have actually dropped when speed limits were *raised* and accident rates have decreased.

Service Efficiency of Routes

When driving speeds are consistent with legal limits, we have at least partial evidence of an adequacy and reasonableness of limits and control. In determining the consistency or lack of it between travel rates and speed limits, it is important to consider traffic delays and the uniformity of flow.

Speed and delay, or time-zone studies, provide a ready and reliable means of determining the service efficiency of routes. In addition to the degree of observance of speed limits, such studies show many things that traffic engineers and others need to know in order to properly plan improvements in routes and controls to provide greater efficiency in highway transportation.

The value of time-saving to motorists has often been questioned. Ten minutes saved by engineering and enforcement may be wasted by the motorist in a "bull session." Even if time is wasted—and that is a matter of opinion—and if small units of time are not appreciated at the moment, small savings accumulate over an area or route to produce appreciably large units. Stop-and-go traffic conditions and unreasonable speed limits may add up to appreciable economic loss, irritation, and gross indifference to regulation, in addition to resentment to facilities and controls provided, or sanctioned, by public officials. Speed limits and driving velocities, therefore, should receive serious attention.

A Speed Study in Three States

To measure deviations between posted limits and driving speeds, and to study general speed characteristics, a survey was conducted over a 500-mile section of a principal north-south U.S. Route through three southeastern states. In the study, accepted speed-and-delay survey methods were used. Care was taken to travel at the speed of most drivers on a given section of roadway. The object was to "float" or "drift" with traffic and to have the test vehicle become as nearly as possible an "average" car in the traffic stream.

Records were made of speeds, distances, and delays. All traffic stops were classified as delays and the reason for each recorded. Every posted speed limit was related to other survey values. Frequent control-readings were recorded so that all data could be related not only to posted limits, but to corporate limits, significant physical landmarks, pavement types and widths, and any unusual conditions of traffic. Conditions of weather and light were also recorded.

It is recognized that limitations were imposed when only a single test run was made. Accordingly, results cannot be taken as absolutely

indicative of normal conditions for the route. If the speeds differ from the normal, however, they should be lower, for the study was made on Saturday, and part of it was at night in the rain.

The Route Described

The route over which the study was made traverses predominantly rural areas. No unusual traffic volumes were observed. Passenger vehicle traffic predominated. Truck traffic appeared about the same as that found on most through-highways in southeastern states.

Most of the route was over the two-lane type highway—413 miles, or 82 per cent of the total as shown in Table I. Three-lane highways constituted 48 miles, or ten per cent of the total mileage. A four-lane divided type road constituted six per cent of the total—30 miles. The rest of the distance, approximately 10 miles, was over four-lane undivided pavement, mostly in urban areas.

Table I

Distances Traveled by Type of Road

Type Road	*Miles Traveled*	*Per Cent of Total Trip*
2 lane	413	82
3 lane	48	10
4 lane, undivided	9	2
4 lane, divided	30	6
Total	500 miles	100%

Four hundred and thirty-one miles, 86 per cent of the total trip, extended through rural areas. The mileage in suburban and urban areas was about equal, approximately 35 miles of each type. A breakdown of the mileage by area types is shown in Table II.

Table II

Distances Traveled by Type Area

Type Area	*Mileage*	*Per Cent of Total Trip*
Rural	431	86
Suburban	35	7
Urban	34	7
Total	500 miles	100%

Posted Speed Limits

During the entire 500-mile trip, eight different posted speed limits were observed. Table III shows the limits in rural, suburban and urban areas. The close relationship between limits in suburban and urban areas indicates that population density and roadside activity are not being considered in assigning speed limits to routes on the outskirts of congested areas.

Table III

DISTANCES POSTED BY VARIOUS SPEED LIMITS

Posted Speed Limit (m.p.h.)	*Rural Areas*		*Suburban Areas*		*Urban Areas*		*Total Mileage by Each Speed*
	Mileage	*% of Total*	*Mileage*	*% of Total*	*Mileage*	*% of Total*	
15 and 20	0.6	0.1	2.8	0.6	4.9	1.0	8.3
25	52.1	10.4	15.0	3.0	14.4	2.9	81.5
30	26.1	5.2	5.5	1.0	11.4	2.4	43.0
35	18.9	3.8	9.2	1.8	3.3	0.7	31.4
40	4.8	1.0	2.5	0.6	–	–	7.3
45	–	–	–	–	–	–	–
50	269.1	53.7	–	–	–	–	269.1
55	59.4	11.8	–	–	–	–	59.4
Totals	431.0	86.0	35.0	7.0	34.0	7.0	500.0

Maximum Speeds

The maximum speed of travel was 65 m.p.h. and this speed was achieved principally for relatively short distances in open areas. In several instances, the speed of 65 m.p.h. was attained in suburban districts, but in most cases, it was reached in open rural places. In a few instances, a speed of 50 m.p.h. was recorded within the corporate limits of cities and towns. But, as previously indicated, these speeds were typical of speeds noted in the areas, and not an attempt to "see how fast we could go!"

Driving Speeds vs. Posted Speeds

Figure 1 shows a comparison of posted speed limits and travel speeds for a typical 60-mile section of the route studied. The curve repre-

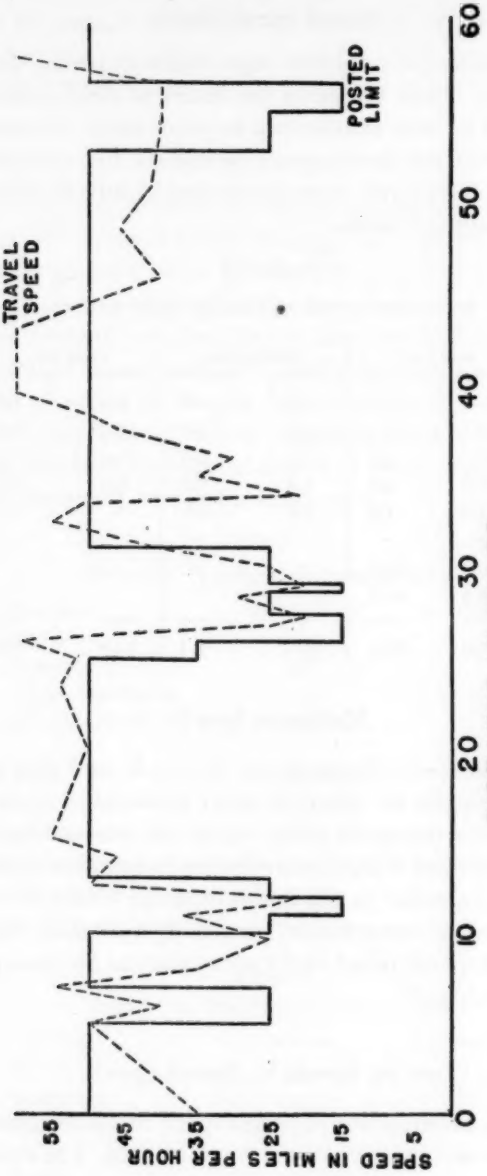

FIG. 1. Comparison of posted limits and travel speeds for typical 60 mile section of route.

senting travel speed follows generally the same pattern as the posted limits but wide discrepancies may be observed at specific locations. The posted speed limit, for example, drops from 50 m.p.h. to 25 m.p.h. at mile 53.0, and then drops to 15 m.p.h. at mile 55.2. Yet the travel speed of the traffic stream shows little deviation along this portion of the route, varying between 42 and 40 m.p.h.

The average driving speeds in rural, suburban, and urban areas are related to the posted limits in Table IV. Also indicated in Table IV are the percentage values by which posted limits were exceeded in the respective areas. It is interesting to note, for example, that where 15 m.p.h. limits were posted in rural areas, an average driving speed of 42 m.p.h. was recorded—a 250 per cent differential. But in urban areas posted for 15 m.p.h., the average speed was only 23 m.p.h. This, by comparison, can be termed "good" observance, yet the average speed is still 55 per cent higher than posted.

Table IV

DRIVING SPEEDS RELATED TO POSTED SPEED LIMITS

Posted Limit	*Average Driving Speed (Floating)*			*Per Cent by Which Limits Exceeded*		
	Rural	*Suburban*	*Urban*	*Rural*	*Suburban*	*Urban*
15	42	30	23	250%	100%	55%
25	51	42	35	104	66	41
30	50	44	41	66	47	36
35	53	47	44	51	35	26
40	50	45	•	25	13	•
50	58	34	•	16	−35	•
55	60	•	•	9	•	•

Where 25 m.p.h. was posted in *rural* areas, average speeds were double the posted speed. Where 25 m.p.h. limits were posted in *urban* areas, the average speed exceeded the posted speed by only 10 m.p.h.

In Figure 2, average travel speeds are related graphically to the posted limits in rural, suburban, and urban areas. The widest discrepancies, as already indicated, occur where the limits are low. At the higher limits in rural areas, the differences between the observed speeds and the posted speeds are slight. In suburban districts the

• No mileage posted at these limits.

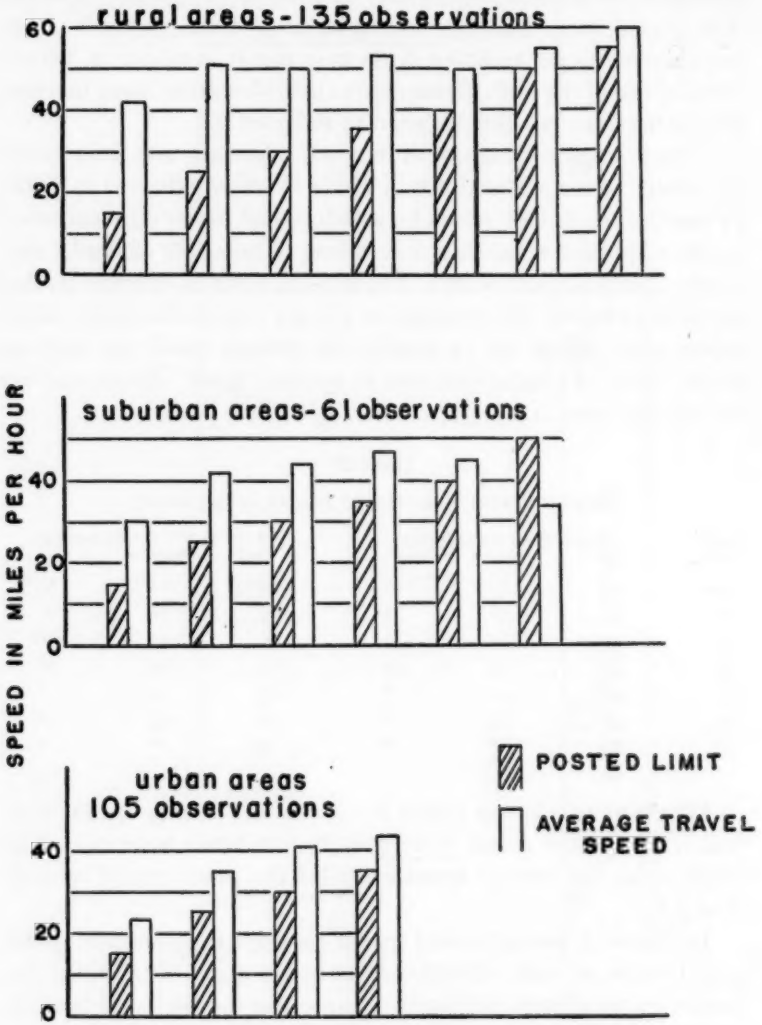

FIG. 2. Average travel speeds observed for various posted speed limits.

principal differences occur where the posted speeds are 35 m.p.h. or less. Where higher speed limits are indicated for suburban areas, the travel speeds are more often actually lower than the posted speed.

The differential between average travel speeds and posted speeds in urban areas was almost constant for all limits found. It varied only from about 7 to 10 m.p.h. and was just as great where the posted limits were 15 m.p.h. as where they were 35 m.p.h. Lowest limit posted was 15 m.p.h. in urban areas; the highest was 35 m.p.h.

Invariably it was noted that the higher the limits the nearer the agreement between the posted and driving speeds. In 35 m.p.h. rural zones, average speeds of 53 m.p.h. were recorded, but in urban places where 35 m.p.h. limits were posted average speed was only 44 m.p.h. Fifty m.p.h. speed zones on rural roads developed an average driving speed of 58 m.p.h. In several cases, where 50 m.p.h. zones were found in suburban areas, the average speed was only 34 m.p.h. This indicates clearly that motorists did not fix their speeds entirely on the basis of posted speed limits, but that other factors, which to them were more important, were used as the basis for driving speeds.

For the highest posted limit found on the route, 55 m.p.h., the average driving speed was 60 m.p.h. The 55 m.p.h. limit was observed only in rural areas. In these cases, the average driving speed was 9 per cent higher than the posted limits.

In relating the 135 speed readings recorded in urban areas to the posted limits, it was found that in 24 cases, 18 per cent, the travel speed was the same as the posted limit. In 35 cases, or 26 per cent, the travel speed was less than the posted speed and in the remaining 76 instances, 52 per cent of the total, the travel speeds exceeded the indicated legal speeds.

In the 61 recordings in suburban areas, the travel speed was exactly the same as the posted speed in only 8 instances, or 13 per cent. Twelve, or 20 per cent, of the speed readings were less than the indicated limits. Forty-one, 61 per cent, were higher than the posted limits.

One hundred and five readings were taken in urban areas. Twenty-one, or 20 per cent, were the same as the posted speed; 39, or 37 per cent, were less than the posted limits; and 45, or 43 per cent, exceeded posted speed values.

Time Saved

The actual travel time for the 500-mile trip was 11 hours and 36 minutes. Had it been possible to drive at exactly the posted values throughout the entire trip, 12 hours and 48 minutes would have been required. This means that by traveling at normal traffic speeds, a saving of 1 hour and 12 minutes was effected. Legal limits could not have been exactly maintained throughout the trip; therefore if the limits had not been exceeded, the differential in time would have been greater.

The relationship between various speed limits and the total mileage of highway controlled by each is shown in Table III. In Table V the time that would have elapsed in traveling the respective distances at exactly the posted limits, the time actually required, and the time-savings for each type of speed limit are also shown.

Table V

RELATIONSHIP OF TRAVEL TIMES TO COMPUTED TIMES FOR DIFFERENT SPEED LIMITS

Speed Limits m.p.h.	*Distance Miles*	*Computed Time Minutes*	*Driving Time Minutes*	*Time Saved Minutes*
15	7.4	30	27.2	2.8
20	0.9	3	2.7	0.3
25	81.5	196	177.5	18.5
30	43.0	86	78.0	8.0
35	31.4	54	48.9	5.1
40	7.3	11	9.7	1.3
50	269.1	323	293.0	30.0
55	59.4	65	59.0	6.0
Total	500	768 or 12 hrs. 48 min.	696 min. or 11 hrs. 36 min.	72.0

Speed Distribution

In Figure 3, the cumulative time spent at or below given speeds is indicated. Excessive speeds are lacking. In fact, 60 per cent of the total time was spent at speeds of 50 m.p.h. or less. Speeds in excess of 55 m.p.h. were recorded for less than 20 per cent of the total travel

time. The speed range 25 to 55 m.p.h. was by far the most common. Approximately 70 per cent of the total travel-time was within this speed range.

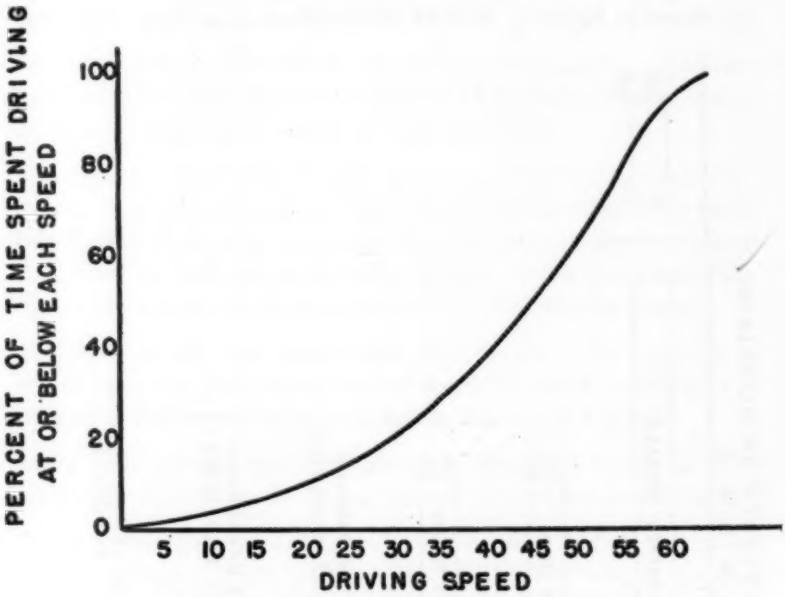

FIG. 8. Time spent driving at or below given speeds.

Delays

In the entire 500-mile trip, 65 delays were recorded; an average of one stop for each 7.7 miles traveled. As would be expected, most of the delays occurred in urban areas where a frequency of one stop each half mile was required.

Most of the required stops were for traffic signals, 47, or 72 per cent of the stops. Six stops were made for stop signs and another six were occasioned by other vehicles making left turns. It was necessary to stop five times during the entire trip because of interferences created by parking maneuvers. Three of these stops were caused by vehicles entering parking spaces; two resulted from unparking ac-

tions. In addition to the stops caused by signals, stop signs, turning and parking, a single stop was necessitated by a general traffic blockade.

Frequency of delays and the percentage of each to total stops are shown in Figure 4. Most of the required stops were short. The

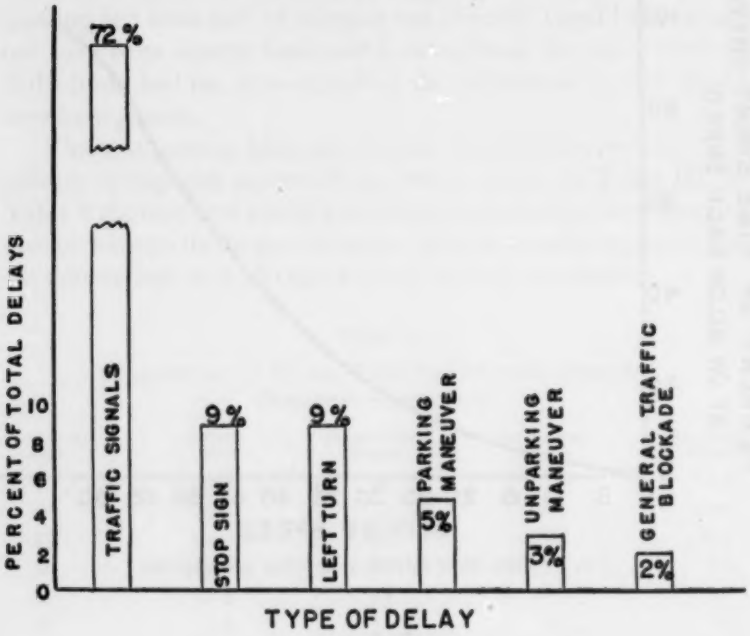

FIG. 4. Unavoidable delays.

longest approximated 30 seconds at a traffic signal. From this, it is evident that average travel-speeds were reduced only slightly by traffic delays and that "irritation" effects were more serious than time-losses.

All voluntary stops were recorded and the time deducted from the total so that such stops did not enter into calculations of average speeds, travel times, and other values.

While other delays were experienced by slow-downs, only those necessitating stops were recorded. The traffic was so light through-

out most of the trip that passing slow-moving trucks and automobiles did not create a serious problem.

COMMENTARY

From the survey data and from general observations, significant factors can be noted that relate not only to the route studied, but to many other important arteries of highway travel.

It is apparent that speed laws are obeyed by motorists in direct relation to their reasonableness. This means that when limits are established, they must be chosen carefully, they must be reasonable and they must be enforced uniformly. Because of the many variables, these objectives are difficult to accomplish with blanket limits.

Motorists do not seek abnormally *high* speeds. The top rates of travel were not great. Most drivers attach far more significance to over-all averages and to uniform speeds than to *crest* speeds.

More uniformity is needed in state speed laws. Why should there be wide differences in the limits just because a state boundary is crossed?

Speed regulations must constantly be reviewed and altered in the light of changes in the roadway, new roadside developments, and different traffic characteristics.

Stronger control should be exercised by the states over speed limits in corporate places. Too many cases were noted where local authorities had posted limits at the corporate boundaries that were arbitrary and restrictive beyond all reason and judgment.

Where proper speed control and driving advice cannot be achieved through blanket speed limits, technical speed zoning should be employed.

Marking Deficiencies

In many instances, serious deficiencies were noted in posted speed limits. For example, there was a considerable mileage of rural road for which 15 to 35 m.p.h. limits were indicated. This condition

might have been due to faulty maintenance of limit signs, or to some oversight on the part of highway officials. Nevertheless, if the limits indicated by signs were to be interpreted by motorists (and there was no other indication) as the legal limits, then unreasonable restrictions prevailed.

In other cases, abnormally high limits prevailed in cities, insofar as posting was concerned, because there was no evidence of speed signs at or within the urban limits. Here, again, the fault might have been in the maintenance of the signs, or it might have involved a policy (unknown to out-of-state motorists) of not erecting signs to advise drivers of special urban limits. In each instance, the motorist's only guides were the signs in place, and it was on the basis of the limits they indicated that data in the survey were compiled.

Uniform speed signs should be carefully erected and maintained, with consideration for both day and night visibility and legibility.

Based on speeds used by local drivers, enforcement officials permit liberal tolerances in the enforcement of posted limits. Yet these vary widely from one state to another and between towns. Uniform speed enforcement policies should be coupled with uniform speed laws.

Motorists Fix Speeds

Except where unusually strict enforcement can be effected, motorists are inclined to fix their own driving speeds, regardless of posted limits. The hoax of attempting to frighten motorists into driving at unreasonably low speeds by fixing absurdly low speed limits should be abandoned.